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APPLICATIONS OF BRUNT'S RADIATION EQUATION TO MINIMUM TEMPERATURE FORECASTING

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During the last quarter century numerous studies have been directed toward the development of methods for forecasting minimum temperatures by the use of empirical mathematical formulae. While many such formulae have been suggested, it appears to the writer that they are quite generally identical in principle and differ from one another only with respect to the general form of equation used to represent the minimum temperature as some function of preceding temperature and/or hygrometric. This paper presents the results of applications of an entirely new form of radiation equation to minimum-temperature forecasting in two southern California fruit-frost districts and compares the values obtained with those derived through empirical formulae already in use in these districts.

The minimum temperature formula in general use today throughout all fruit-frost districts on the Pacific coast was developed by Young (1) and takes the general form:

$$T=d-\frac{h-n}{4}+V_d+V_h \qquad (1)$$

where d and h are the 4:40 p. m. dewpoint and relative humidity; V_d and V_h are corrections which depend upon dewpoint and relative humidity; and n is a number which varies between districts and with cloudiness. For both the Riverside and El Centro key stations used in this study, n takes the value of 30 for clear or partly cloudy nights and 35 for cloudy nights.

It is not the purpose of this paper to analyze the various types of empirical minimum-temperature formulae; this has been accomplished by Ellison (2), who also presents a quite complete bibliography of the subject up to 1928. An examination of equation (1), however, reveals that the only variables in the formula are dewpoint and relative humidity. Since it is built up from hygrometric and minimum temperature data plotted together on a dot chart, other factors which affect the rate of temperature fall are indirectly included and it is not possible to subsequently remove these factors singly for analysis.

While these empirical formulae appear to succeed exceedingly well in areas where wind is lacking and low clouds are of infrequent occurrence on frost nights, they are not so successful in windy or cloudy districts.

According to Brunt (3, p. 125),"* * * the net outward radiation at night from the earth's surface depends only on atmospheric conditions and on the temperature of the earth's surface." Nevertheless, the temperature changes in the earth's surface produced by a given amount of radiation depends upon the rate at which heat is conducted to the surface from below to replace that lost through radiation. This rate, in turn, depends upon the density (π_1), specific heat (c_1), and the specific conductivity of heat (κ_1) of the soil surface. Values for density and specific heat of various types of soils are given in tables 1 to 3. Johnson and Davies (4) have computed values of κ_1, but give results for one type of soil only. If soil thermographs are available, however, this coefficient

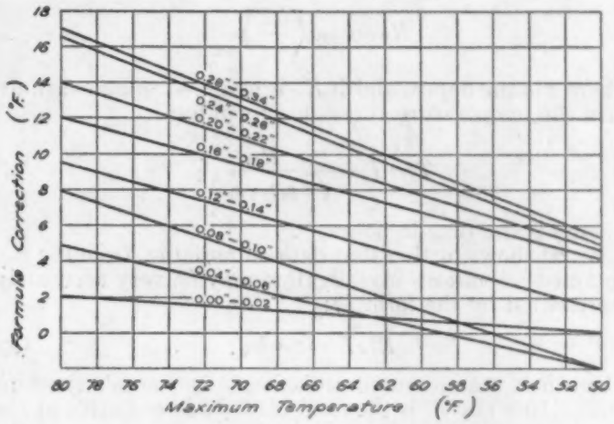

FIGURE 1.—Minimum-temperature-formula correction based on maximum temperature and pressure differences between Tonopah and Los Angeles.

may be computed (4) for any soil from measurements of lag in time of occurrence of maximum temperature at two depths by using the following expression:

$$\kappa_1=\frac{t\,(z_2-z_1)^2}{4L^2\pi} \qquad (2)$$

where t is 24 (hours), z_2 and z_1 are two depths in the soil, and L is the lag in time (seconds) of occurrence of maximum temperature at depths z_1 and z_2.

TABLE 1.—*Specific gravities of composite soil separates: Whitney* [1]

Conventional name	Particle diameter	Specific gravity
	(*mm*)	
Fine gravel	2 –1	2.647
Coarse sand	1 –.5	2.655
Medium sand	.5 – .25	2.648
Fine sand	.25 – .10	2.659
Very fine sand	.1 – .05	2.680
Silt	.050– .005	2.698
Clay	.005– .000	2.837

[1] *Soils*, Lyon and Fippin, Macmillan Co., N. Y. 1912. 5th Ed. p. 95.

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TABLE 2.—*Specific heat of soils (equal weights)* [1]

Soil type	Specific heat	Soil type	Specific heat
Norfolk sand	0.1848	Podunk fine sandy loam	0.1828
Hudson River sand	.1769	Leonardtown silt loam	.1944
Fine sand (soil separate)	.1799	Hagerstown loam	.1914
Fine quartz flour	.1900	Galveston clay	.2097
Coarse sand (quartz)	.1900	Muck soil (25 percent organic matter)	.1566

[1] Patten, H.E., Bulletin 59, Bureau of Soils, U.S.D.A. 1909, p. 34.

TABLE 3.—*Effect of moisture on the specific heat of Podunk fine sandy loam* [1]

Moisture content (percent of dry weight)	Specific heat	Moisture content (percent of dry weight)	Specific heat
0.268	0.1850	6.60	.2324
1.33	.1935	10.08	.2575
2.14	.2000	20.25	.3204
2.83	.2053	26.93	.3562

[1] Specific Heats of Soils: Patten, H. E., Bulletin 59, Bureau of Soils, U. S. D. A.

Brunt concludes that the net loss of heat by radiation from the ground, R_N, is:

$$R_N=\kappa_1\rho_1c_1\left(\frac{\partial T}{\partial z}\right)_{z=0} \tag{3}$$

where z is the depth, and if R_N is assumed to be constant, then the temperature at $z=0$ is given by:

$$T_1=T_0-\frac{2}{\sqrt{\pi}}\frac{R_N}{\rho_1c_1\sqrt{\kappa_1}}\sqrt{t} \tag{4}$$

where t is the time in hours.

Brunt shows further that data on radiation from the sky obtained by various investigators may be very accurately represented by the formula:

$$R/\sigma T^4=a+b\sqrt{e} \tag{5}$$[1]

where R is the measured radiation, σ is Stefan's constant (8.22×10^{-11}), σT^4 is the total black body radiation at the surface temperature T, and e is the vapor pressure at the surface (in mb). He obtains somewhat different values for a and b in the cases of various sets of data but suggests that instrumental causes probably account for these differences.

In view of the fact that the fall in temperature during the night is only a small part of T, it may be assumed as a first approximation that R_N is constant, and since:

$$R_N=\sigma T^4(1-a-b\sqrt{e}) \tag{6}$$

then, by combining equations (4) and (6), he obtains:

$$T_1=T_0-\frac{2\sigma T^4}{\sqrt{\pi}}\left(\frac{1-a-b\sqrt{e}}{\rho_1c_1\sqrt{\kappa_1}}\right)\sqrt{t} \tag{7}$$

where T_0 is the air temperature at sunset.

By assigning values for ρ_1, c_1, and κ_1 (tables 1 to 5), appropriate for the soil conditions at the Riverside key station, and taking the mean of the values for a and b given in table 6, and assuming T constant at 280°, then equation (7) for the Riverside station becomes:

$$T_1=T_0-12.1\ (0.56-0.08\sqrt{e})\ \sqrt{t} \tag{8}$$

where T_0 is the 4:40 p. m. air temperature. By taking t constant at 13.5 hours,[2] equation (8) may be further simplified to:

$$T_1=T_0-44.5\ (0.56-0.08\sqrt{e}) \tag{9}$$

Using the appropriate soil constants, equation (7) for the El Centro key station becomes:

$$T_1=T_0-45.24\ (0.56-0.08\sqrt{e}) \tag{10}$$

TABLE 4.—*Specific conductivity of heat of soils* [1]

[Calculation of κ from time lag]

Z_1 (cms.)	Z_2 (cms.)	L (hours)	κ from eqn. 1
2.54	7.5	1.55	5.7×10^{-3}
2.54	15.25	4.5	4.2×10^{-3}
2.54	30.5	10.1	4.1×10^{-3}
		Mean [2]	4.7×10^{-3}

[1] Johnson and Davies. Q. J. Roy. Met. Soc. 33, 22, 1927.

[2] In one series during a period without rainfall, they found the value of κ to be 0.0035 and for a series during a period with heavy rainfall, a value of 0.0041, a difference of 0.0006. This difference is due to the fact that the water which replaces the air in the soil has a higher conductivity than the air.

TABLE 5.—*Relative conductivity of soil material* [1]

Soil material	Dry		Wet
	Loose	Compact	
Quartz powder	100.0	106.7	201.7
Peat	90.7	90.7	94.3
Kaolin	90.7	96.4	155.6
Chalk	85.2	92.6	153.2
Clay with limestone stones	112.1	----	----
Clay with quartz stones	115.6	----	----
Quartz sand (fine)	100.0	----	----
Quartz sand (medium)	103.6	----	----
Quartz sand (coarse)	105.3	----	----
Quartz sand	100.0	174.0	189.0

[1] Relative Conductivity of Soil Material; Pott, H. E., Landw. Versuchs-Stationen, XX, p. 288.

TABLE 6.—*Values of a and b determined by various investigators* [1]

	a	b	Range of e (mb.)
Dines (Benson)	0.52	0.65	7–14
Asklöf (Upsala)	.43	.082	2–8
Angstrom (Bassour)	.48	.058	5–15
Boutaric (France)	.60	.042	3–11
Robitsch (Lindenberg)	.34	.110	3–22
Ramanathan and Desai (Poona)	.26	.120	8–18
Mean	.44	.080	----

[1] Brunt, D., Physical and Dynamical Meteorology, 1934, p. 124.

The results of applying Brunt's equation to minimum-temperature forecasting on 25 clear nights at the Riverside station when temperatures fell to 34° F or lower at some station in the Corona district, are given in table 7. This station exemplifies excellent radiation conditions and the empirical minimum temperature formula is quite successful. It may be observed that the minimum temperature computed after Brunt averages too low for the observed minimum temperatures at this station. This is the expected result when it is considered that the effects of wind on retarding the temperature fall by mixing the surface layers of air, are not taken into consideration by this equation, whereas the empirical formula in use at the station tends to raise the formula estimate in cases of low vapor pressures, which are, in these districts, generally indicative of wind.

[1] Equation (5) should be regarded as entirely empirical with the strictly theoretical justification in doubt.

[2] A difference of 1 hour for t in equation (8) (between $t=13$ and $t=14$) would result in an error of only 0.6° C in the formula estimate at the mean vapor pressure for this station.

It may also be observed that the average departure of the computed minimum temperature from the observed is greater in the case of Brunt's equation than in the case of the empirical formula. Since the empirical formula, however, is built up from mean conditions, it should be less erratic than the equation obtained by fitting Brunt's formula to the temperatures and vapor pressures at a particular hour.

TABLE 7.—*Computed and observed minimum temperatures for the Riverside key station on clear nights with minimum temperatures below 34° F. at some station in the district*

1937-38	4:40 p. m. air temperature	4:40 p. m. vapor pressure	Formula temperature (Brunt)	Formula temperature (Young)	Minimum temperature following a. m. in shelter	Formula temperature (Brunt) minus shelter temperature	Formula temperature (Young) minus shelter temperature	Wind (4:40 p. m.) Beaufort
	°C	Mb.	°C	°C	°C	°C	°C	
Nov. 26	15.6	10.1	2.0	1.7	2.2	−0.2	−0.5	Light.
27	17.2	10.1	3.6	2.8	1.7	+1.9	+1.1	Do.
Dec. 6	16.1	8.0	1.2	.6	−.6	+1.8	+1.2	Do.
7	15.0	8.0	.1	.0	.0	+.1	.0	Do.
14	12.8	10.5	−.6	.6	1.1	−1.7	−.5	Do.
15	13.3	10.9	.1	1.1	2.2	−2.1	−1.1	Do.
16	13.3	10.9	.1	1.1	2.2	−2.1	−1.1	Do.
18	19.4	5.3	2.7	.6	1.1	+1.6	−.5	Moderate.
20	12.8	2.9	−6.0	−1.1	1.1	−7.1	−2.2	Do.
21	11.7	5.8	−4.6	−2.2	−2.2	−2.4	.0	Light.
24	8.3	9.4	−5.7	−.6	−.6	−5.1	.0	Do.
Jan. 3	12.2	11.7	−.5	.0	1.7	−2.2	−1.7	Do.
4	16.7	6.9	1.1	−.6	.0	+1.1	−.6	Do.
5	16.7	6.9	1.1	−.6	−1.7	+2.8	+1.1	Do.
6	13.3	8.4	−1.3	1.1	.0	−1.3	+1.1	Do.
8	16.7	3.8	−1.3	−.6	.0	−1.3	−.6	Moderate.
22	15.6	9.4	1.6	1.7	.0	+1.6	+1.7	Light.
23	18.3	3.6	.1	−.6	.6	−.5	−1.2	Moderate.
24	14.4	3.8	−3.6	−1.1	−1.1	−2.5	.0	Gentle.
25	16.1	3.5	−2.1	−1.1	1.1	−3.2	−2.2	Moderate.
29	9.4	10.9	−3.8	.6	−1.1	−2.7	1.7	Light.
Feb. 1	11.1	6.9	−4.5	−.6	1.7	−6.2	−2.3	Do.
6	15.0	5.8	−1.3	−1.1	−1.1	−.2	.0	Do.
12	10.6	8.7	−3.8	−1.1	−1.1	−2.7	.0	Do.
13	10.6	8.0	−4.3	−1.7	.0	−4.3	−1.7	Do.
Mean	14.1	7.6	−1.2	0.	.3	[1] 2.3	[1] 1.0	
Mean (°F)	57.4	(2)	29.8	32.0	32.5	[1] 4.1	[1] 1.8	

[1] Average departure regardless of sign.
[2] Mean dewpoint 38° F.

Brunt's equation was also applied to data accumulated on 25 clear nights at the El Centro key station (table 8) where empirical formulae are not so successful. It was found that the formula estimate computed after Brunt tended to average slightly too high while the mean departure from the actual minimum temperature was quite large. It may be remarked in this connection that the 4:40 p. m. observation at El Centro is made in a grapefruit grove several miles from town and, as a result of transpiration from foliage and local irrigation in the vicinity of the station, vapor pressures average much too high to be representative of vapor pressures over the valley as a whole. This is evidenced by comparing the 4:40 p. m. dewpoints with those obtained at an urban station in El Centro at 7 p. m. The latter dewpoints are invariably lower than those obtained in the grove. For the data in table 8, the 7 p. m. dewpoints average 6° F. lower than those at 4:40 p. m.[3] with a maximum difference of 15.5° F. on January 23. This mean difference in dewpoints would lower Brunt's estimate from 1° C. to 2° C. It has not been deemed advisable to substitute these 7 p. m. vapor pressures in Brunt's equation, however, since the El Centro empirical formula has been constructed from data obtained at the grove station and it was desired to compare the two formulae by using identical data.

[3] This difference in mean dewpoints is too great to be assigned to purely diurnal effects

TABLE 8.—*Computed and observed minimum temperatures for the El Centro key station on clear nights with minimum temperatures below 32° F. at some station in the district*

1937-38	4:40 p. m. air temperature	4:40 p. m. vapor pressure	Formula temperature (Brunt)	Formula temperature (Young)	Minimum temperature following a. m. In shelter	Formula temperature (Brunt) minus shelter temperature	Formula temperature (Young) minus shelter temperature	Wind (mean) Beaufort
	°C	Mb	°C	°C	°C	°C	°C	
Dec. 6	16.2	11.5	3.1	3.1	1.7	+1.4	+1.4	Light.
21	12.1	8.3	−2.8	.3	−.7	−2.1	+1.0	Calm.
Jan. 5	15.0	10.9	1.6	1.8	−.3	+1.9	+2.1	Do.
6	15.9	8.7	1.2	.8	.6	+.6	+.2	Do.
8	13.7	8.9	−.9	.9	.8	−1.7	+.1	Light.
9	17.3	5.0	.1	−1.2	−.1	+.2	−1.1	Do.
10	14.6	7.2	−1.0	−.8	−.4	−.6	−.4	Do.
11	16.2	9.6	2.1	1.8	.0	+2.1	+1.8	Calm.
12	17.9	8.7	3.2	1.6	.0	+3.2	+1.6	Do.
16	16.9	11.0	3.6	2.9	1.9	+1.7	+1.0	Do.
17	21.6	11.4	8.5	3.8	4.3	+4.2	−.5	Moderate.
20	13.6	6.2	−2.7	−1.7	6.3	−9.0	−8.0	Do.
21	17.9	6.4	1.7	−.1	.8	+.9	−.9	Light.
22	20.7	8.5	6.0	2.3	−.7	+6.7	+3.0	Calm.
23	18.7	8.9	4.0	2.1	−2.3	+6.3	+4.4	Do.
24	13.1	5.1	−4.0	−2.7	−1.9	−2.1	−.8	Light.
25	12.2	5.9	−4.4	−2.6	−.6	−3.8	−2.0	Do.
26	16.0	7.1	.2	−.3	−.1	+.3	−.2	Calm.
27	17.8	8.6	3.1	1.4	−.1	+3.2	+1.5	Do.
30	15.6	8.5	.9	.9	−.5	+1.4	+1.4	Do.
Feb. 1	15.7	15.2	4.5	4.3	1.8	+2.7	+2.5	Light.
2	16.1	9.0	1.6	1.2	4.9	−3.3	−3.7	Do.
4	18.2	8.4	3.4	1.4	5.5	−2.1	−4.1	Moderate.
13	17.1	5.9	.5	−1.1	5.6	−5.1	−6.7	Light.
17	10.6	6.4	−5.6	−2.2	−1.2	−4.4	−2.0	Calm.
Mean	16.0	8.4	+1.1	+0.7	+1.0	[1] 2.8	[1] 2.1	
Mean (°F)	60.8	(2)	34.0	33.3	33.8	[1] 5.0	[1] 3.8	

[1] Average departure regardless of sign.
[2] Mean dewpoint 40° F.

Values obtained by applying Brunt's equation (with T constant at 273°) to data collected at El Centro during the freeze of January, 1937, are presented in table 9. Evidently the vapor pressures obtained during this period when wind movement was fairly rapid and consistent, were more representative of conditions over the district since the computed minimum temperatures average considerably lower than the observed. These values are interesting in that they give some idea as to how low temperatures might have fallen in the El Centro district if factors such as wind, and the effects of general irrigation for frost protection, had not interfered with the temperature fall.

TABLE 9.—*Computed and observed minimum temperatures at El Centro for the freeze of January 1937*

1937	4:40 p. m. air temperature	4:40 p. m. vapor pressure	Formula temperature (Brunt)	Formula temperature (Young)	Actual minimum temperature following a. m. in shelter	Formula temperature (Brunt) minus shelter temperature	Formula temperature (Young) minus shelter temperature	Lowest temperature in district
	° C.	mb	° C.	° C.	° C.	° C.	° C.	° C.
Jan. 8	6.1	4.8	−9.5	−5.6	−6.0	−3.5	+0.4	−7.2
9	3.8	4.8	−11.8	−5.6	−5.0	−6.8	−.6	−6.7
10	7.3	5.1	−8.1	−4.4	−4.4	−3.7	.0	−5.6
21	4.4	1.6	−14.2	−9.4	−9.5	−4.7	+.1	−11.1
22	4.1	1.6	−14.5	−9.4	−7.2	−7.3	−2.2	−11.1
23	5.6	2.4	−10.9	−6.7	−7.8	−3.1	+1.1	−8.8
24	12.2	6.6	−2.2	−1.7	−5.2	+3.0	+3.5	−6.7
25	10.0	4.1	−6.1	−3.9	−5.0	−1.1	+1.1	−8.9
26	10.9	4.1	−5.2	−3.9	−4.4	−.8	+.5	−6.7
Mean	7.2	3.9	−9.2	−5.6	−6.1	[1] 3.8	[1] 1.1	−8.1
Mean: (° F.)	45.0	(2)	15.4	21.9	21.0	[1] 6.8	[1] 2.0	17.4

[1] Average departure regardless of sign.
[2] Mean dewpoint 22° F.

Since the net loss of heat by the earth's surface on cloudy nights is diminished by an amount approximately equal to the radiation from the base of the cloud, it should be possible to correct any minimum temperature formula for cloud effects if data regarding radiation from cloud surfaces or the effects of clouds on radiation from the earth, can be obtained. Asklöf (5) presents data on the net radiation from the ground on clear nights and on cloudy nights (table 10) and, while these data are somewhat meager, they may be utilized in this study until more complete observations concerning radiation on cloudy nights are available.

Ångström (6) computes that the net loss of radiation from the ground on cloudy nights is:

$$R_m - (1-0.09m)\,R_0 \qquad (11)$$

where R_m is the net loss of radiation from the ground with m tenths of the sky covered by cloud, and R_0 is the net radiation on clear nights. Ångström's formula, however, obviously cannot deal with clouds of different heights.

TABLE 10.—*Values of K for various cloud heights computed from Asklöf's radiation data*

Cloud type	Average height (km)	Net radiation (Asklöf)[1] (gm-cal./cm²)	$\frac{K^{1}}{\left(1-\frac{R_m}{R_0}\right)}$
Nimbus, stratus or strato-cumulus	1.5	0.023	0.864
Alto-cumulus (alto-stratus)	2.8	.039	.769
Cirro-stratus	6.4	.135	.200
Clear sky	----------	.169	.000

[1] Geog. Annaler, Stockholm, 2, 1920, p. 253.

By taking Asklöf's radiation data contained in table 10, it is possible to compute a correction (K) for cloudiness to be applied to Brunt's equation such that:

$$K=1-\frac{R_m}{R_0} \qquad (12)$$

where R_m is the net raidation on a totally cloudy night and R_0 is the net radiation on a clear night. Then if the temperature fall during the night, as computed by equation, is Δt, it follows that:

$$T_1=T_0-\Delta t(1-Km) \qquad (13$$

where m is the number of tenths of sky covered by cloud. By plotting the values for K given in table 10 as a function of cloud height, a curve is obtained which may be approximately represented by:

$$K=0.92-0.005h-0.017h^2 \qquad (14)$$

where h is the height of the base of the clouds above the surface (in kilometers).

The results of applying the correction K to Brunt's estimate of the minimum temperature on 15 nights with clouds at the El Centro key station, are given in table 11.

On first analysis, Brunt's equation appears considerably more accurate than Young's formula for these data. It should be considered, however, that Young's formula has been constructed from data accumulated on cold nights [4] and is therefore intended to apply only on nights which are generally clear or, at most, on nights when clouds clear early in the forecast period. The cloud data contained in table 11 are for mean conditions throughout the night and while it is not usually possible to predict the actual height of clouds during the night or the mean percentage of sky covered by clouds with any great degree of accuracy, the order of magnitude of the temperature correction for varying cloud conditions is well illustrated in the table.

TABLE 11.—*Computed and observed minimum temperatures for the El Centro key station on a series of cloudy nights*

Date 1938	4:40 p. m. air temperature	4:40 p. m. vapor pressure	Formula, temperature (Brunt)	Formula, temperature (Young)	Minimum temperature following a. m. in shelter	Formula, temperature (Brunt) minus shelter temperature	Formula, temperature (Young) minus shelter temperature	Mean: Clouds Amt.	Mean: Clouds Type	Mean: Wind
	°C	mb	°C	°C	°C	°C	°C			
Jan. 8	12.1	9.8	−0.8	0.5	−0.7	−0.1	+5.7	0.1	Ast	Light.
18	21.1	9.7	10.7	4.1	9.9	+.8	−5.8	.3	StCu	Moderate.
19	16.7	8.3	8.5	.9	7.5	+1.0	−6.6	.5	StCu	Do.
29	13.1	9.8	.4	1.8	−.4	+.8	+2.2	.1	StCu	Calm.
31	13.6	6.6	8.6	2.4	7.7	+.9	−5.3	.8	StCu	Do.
Feb. 5	14.4	7.8	1.5	−.2	1.9	−.4	−2.1	.2	ACu	Light.
6	16.6	7.8	2.6	.8	.5	+2.1	+.3	.1	ACu	Do.
7	17.4	7.3	3.4	.4	3.3	+.1	−2.9	.5	CiSt	Calm.
8	15.5	10.6	6.2	1.9	6.7	−.5	−4.8	.4	ACu	Do.
9	16.6	9.5	4.9	1.7	4.3	+.6	−2.6	.2	StCu	Light.
10	21.0	12.8	9.6	4.9	4.9	+4.7	.0	.4	CiSt	Do.
11	21.8	9.0	12.3	2.7	11.1	+1.2	−8.4	.4	StCu	Moderate.
14	18.1	8.2	6.6	1.4	7.3	−.7	−5.9	.3	ASt	Do.
16	13.9	9.1	1.9	1.2	1.6	+.3	−.4	.2	StCu	Calm.
18	13.3	6.6	7.0	−1.3	6.7	+.3	−8.0	.7	St	Do.
Mean	16.3	8.9	5.6	1.5	4.8	[1] 1.0	[1] 4.1	.35		
Mean (°F.)	61.3	(2)	42.1	34.7	40.6	[1] 1.8	[1] 7.4	------		

[1] Average departure regardless of sign.
[2] Mean dewpoint 42° F.

The effects due to the mechanical action of night winds are difficult to determine in the ordinary minimum temperature formula. Such winds are of frequent occurrence in most districts and the tendency, in practically all cases, is to raise the surface temperature through mixing the warmer air aloft with that which is undergoing cooling at the surface. In extreme cases, the temperature inversion may be completely destroyed.

Since the total effect of a given wind velocity on the minimum temperature will depend upon the temperature gradient aloft at low levels, it becomes necessary to obtain some measure of temperatures at heights above the surface. Young (7) has shown that the vertical temperature gradient at low levels is largely a function of the maximum temperature during the day. Johnson (8), in an unpublished paper, has utilized this principle and presents the results of applying a correction to the minimum temperature at Corona, Calif., based upon pressure differences and maximum temperatures. He has taken the pressure difference between Tonopah, Nev., and Los Angeles as being representative of actual existing pressure gradients. It would probably be better to obtain gradients directly from the evening weather map and compute probable wind velocities for these data.

If probable wind velocities for the night can be determined, they should be substituted in figure 1[5] in place of pressure differences. Such corrections, however, cannot be determined until a long series of observations is available.

If meteorological conditions can be assumed to remain constant throughout the duration of the night, then all possible variable factors have been accounted for in the equations which have been presented in this paper. Any significant change in conditions, however, will result in

[4] For frost forecasting purposes, a cold night is defined as one on which the temperature falls to 32° F. or lower, at one or more stations in the fruit-frost district

[5] Fig. 1 was built up from pressure and minimum temperature data accumulated at the Corona key station over a period of 5 years.

errors in any equation used to forecast the minimum temperature. Ångström (9) has introduced a value Δt_s into his minimum temperature formula which takes into account changes of air mass and conditions dependent upon the weather map. It appears to the writer, however, that it would be more logical to analyze the weather map for expected changes in conditions and modify the formula estimate on the basis of these expected changes. For example, it is entirely possible to compute minimum temperatures for air masses which are already present on the evening weather map but which have not yet invaded the region for which minimum temperature forecasts are to be prepared.

CONCLUSIONS

According to Krick (10), Brunt's equation should be more valuable in forecasting minimum temperatures than purely empirical formulae. Nevertheless, it is difficult to determine the proper soil constants with any degree of accuracy and, it its present status, it is far less accurate than the empirical formulae already in use. Since Brunt's equation assumes that the minimum temperature measured in a standard instrument shelter varies directly as the soil temperature in the immediate vicinity of the shelter, it is interesting to compare the extreme variability between temperatures measured in a standard fruit region shelter at the El Centro key station and those recorded by an aluminum-backed minimum thermometer placed directly on the ground approximately 10 feet from the same shelter. These data are presented in table 12. Obviously, Brunt's equation in its present form cannot present minimum temperatures with any greater degree of accuracy than this relationship.

TABLE 12.—*Comparison of minimum temperatures recorded in a standard fruit-region shelter at the El Centro key station to the minimum temperatures recorded by a thermometer exposed on the ground open to the sky*

Date	Minimum temperature in shelter[1]	Minimum temperature on ground[1]	Shelter temperature minus ground temperature	Mean		
				Clouds		Wind
1938	°C	°C	°C	*Amount*	*Type*	
Jan. 16	1.9	0.3	1.6	0		Calm.
17	4.3	2.4	1.9	0		Moderate.
18	9.9	5.3	4.6	0.3	StCu	Do.
19	7.5	2.9	4.6	.5	StCu	Do.
20	6.3	.2	6.1	0		Do.
21	.8	−.9	1.7	0		Light.
22	−.7	−3.4	2.7	0		Calm.
23	−2.3	−6.3	4.0	0		Do.
24	−1.9	−6.9	5.0	0		Light.
25	−.6	−5.1	4.5	0		Do.
26	−.1	−4.4	4.3	0		Calm.
27	−.1	−3.9	3.8	0		Do.
29	−.4	−4.6	4.2	.1	StCu	Do.
30	−.5	−4.7	4.2	0		Do.
31	7.7	4.1	3.6	.8	StCu	Do.
Feb. 1	1.8	−2.7	4.5	0		Light.
2	4.9	−1.4	6.3	0		Do.
4	5.5	0	5.5	0		Moderate.
5	1.9	0	1.9	.2	ACU	Light.
6	.5	−3.7	4.2	.1	ACU	Do.
7	3.3	.8	2.5	.5	CiSt	Calm.
8	6.7	2.9	3.8	.4	ACu	Do.
9	4.3	.8	3.5	.2	StCu	Light.
10	4.9	1.6	3.3	.4	CiSt	Do.
11	11.1	4.9	6.2	.4	StCu	Moderate.
13	5.6	−1.7	7.3	0		Light.
14	7.3	1.6	5.7	.3	ASt	Moderate.
16	1.6	−4.5	6.1	.2	StCu	Calm.
17	−1.2	−6.4	5.2	0		Do.
18	6.7	−.1	6.8	.7	St	Do.
Mean	3.2	−.1	4.3			
Mean (°F)	37.8	30.0	7.8			

[1] Minimum temperature occurs on the morning following the date listed.

In spite of the present inaccuracies of the equation for forecasting purposes, it is believed that its use is highly justified as a supplement to present minimum temperature formulae. It has also proved to be invaluable as a study device.

For example, Brunt's equation in its present form may be used in a qualitative manner to:

1. Give some idea of the time it will be necessary to light orchard heaters on frost nights.
2. Indicate the rapidity with which temperatures may fall during calm periods on nights with low vapor pressures.
3. Compute the order of magnitude of the correction for differences in the length of night.
4. Forecast the probable effects on minimum temperatures of changes in air mass with known vapor pressures and temperatures.
5. Determine the effects of changes in soil moisture and soil cover on the rate of temperature fall.
6. Forecast minimum temperatures for new frost stations where date necessary for the construction of empirical minimum temperature formulae have not yet been collected.

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THE WEATHER OF 1939 IN THE UNITED STATES

By R. J. MARTIN

[Weather Bureau, Washington, D. C. February 1940]

The year 1939 averaged slightly cooler than the preceding year, but was still warmer than normal nearly everywhere in the United States. Precipitation, particularly during the growing season, was subnormal in large central and eastern areas, and in much of the West. For the year as a whole, only 10 of the 42 climatological sections into which the continental United States is divided received normal or above-normal amounts of moisture. The relatively wettest State was Nevada, with only 110 percent of normal.

Table 1 shows that only one section, New England, comprising the six New England States, had below-normal warmth for the year, and here the negative departure was only 0.4°. The State of New Mexico averaged exactly normal for the year, and all other sections were above normal. The relatively warmest was Nebraska with an excess of 3.2°, followed closely by South Dakota with 3.1°. Over much of the country the year averaged more than 2.5° above the yearly mean.

To a remarkable degree the quantitative distribution of positive temperature departures resembled that of 1938. In keeping with recent trends to abnormally warm weather, the year ended with large positive departures, particularly in northern sections, with Minnesota reporting a December that was 10.7° warmer than normal. In South Dakota the excess for December was 10.0°, and in North Dakota 13.7°.

The lithographic chart shows the annual departures of mean temperature from the normal for the year based on first-order stations only. Table 1 contains section or State means, and is more representative of true conditions. Extremes for the year were well within the record extremes for the United States. The lowest temperature reported was 51° below zero at Meadowlands, Minn., on February 21, and the highest maximum was 123° at Greenland Ranch, Calif., on July 13. (The record extremes of temperature for the United States are 134° at Greenland Ranch, and −66° at Riverside Ranger Station, Yellowstone Park, Wyo.) Temperatures of 100° or above were reported in all sections, except New York and Michigan during the course of the year. In these two States maxima of 98° or 99° were reported. Subzero temperatures occurred in all but about seven Southeastern States.

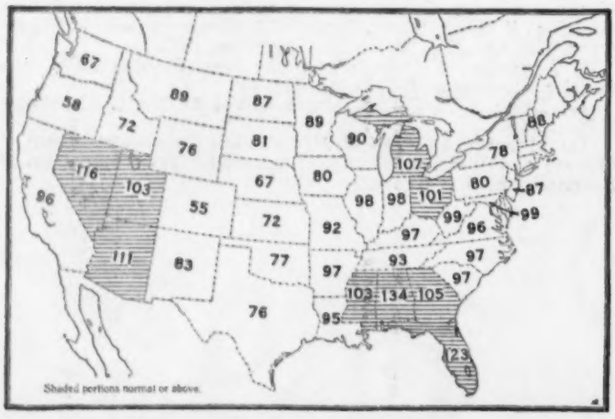


FIGURE 1.—Percentage of normal precipitation, by sections, for the growing season, April 1–September 30, 1939.

Figure 1 shows the percentage of normal precipitation for the growing season, April 1–September 30, 1939. It will be noted that amounts for this 6-month period were above normal in portions of the Plateau and Great Basin area, and also in much of the Southeast from the Mississippi eastward, and were near normal to slightly above in portions of the Ohio Valley and Lake region. The greatest deficiency was in Colorado where some of the year's duststorms were locally as severe as in any previous year. The far Northwest was dry, and other comparatively low percentages occurred in the central and southern Great Plains. In the Northeast, New York, with 78 percent of the normal rainfall for the growing season, was the driest section.

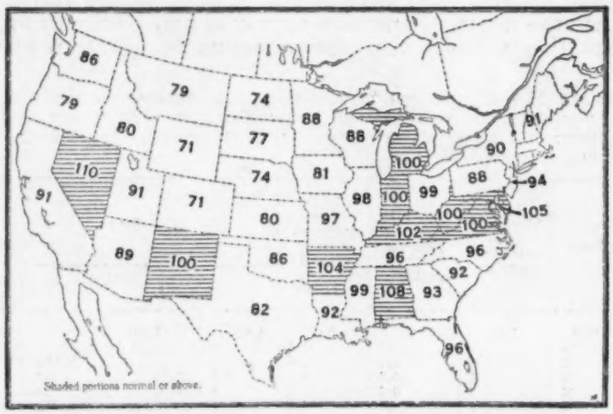


FIGURE 2.—Percentage of normal precipitation, by sections, for the year.

Figure 2 gives the percentage of normal precipitation, by sections, for the year. Only three States west of the Mississippi River were normal or above, while seven sections to east of the Mississippi were normal or above. The relatively wettest State was Nevada with 110 percent of normal.

Deficiencies were most marked in western districts, particularly in the central and northern Great Plains and central Rocky Mountain sections. The relatively driest States were Colorado and Wyoming, each with 71 percent of the usual annual fall.

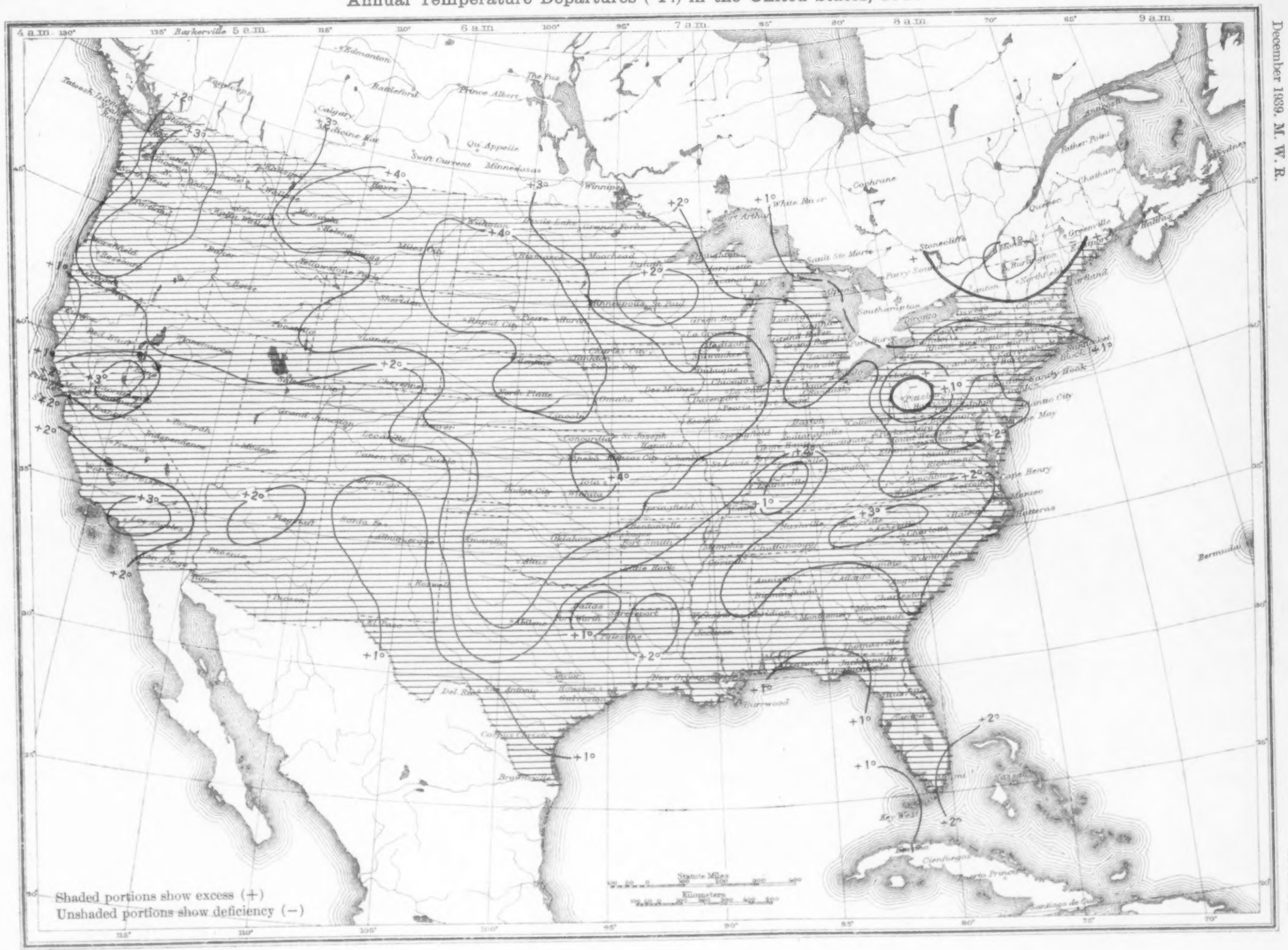
The year was considerably drier than 1938, when most States west of the Mississippi River and over half of those to eastward received above-normal precipitation.

Table 2 shows the percentage of normal precipitation by months for each of the 42 climatological sections. This table, like table 1, is based on section averages, and gives an accurate picture of precipitation distribution throughout the year.

The winter of 1939 (including December of the preceding year) was abnormally wet rather generally in the eastern United States, and in the Southwest, with much the greater portion of the country having above-normal amounts. Heavy snows occurred in most western mountain sections the latter part of the season.

The spring was decidedly dry with only a few States from the Mississippi Valley eastward having somewhat more than normal rainfall. From the Great Plains westward all States had deficiencies.

Annual Temperature Departures (°F.) in the United States, 1939



The summer was relatively wet to eastward of the Great Plains, except in the Northeast, but rainfall was deficient in nearly all sections from the Great Plains westward. The fall season was extremely dry over large areas, although amounts of precipitation were decidedly above normal in Utah, Colorado, and Arizona. From the Rocky Mountains eastward it was the driest fall of record, considering the area as a whole.

Alabama, with 59.33 inches, had the largest average total for the year, and Nevada, with 8.45 inches, the least, although this amount was only slightly below the normal. The total yearly falls in the Great Plains and Central Rocky Mountain States were as follows: North Dakota 14.15 inches, the least since 1936; South Dakota 15.71 inches, also the smallest since 1936; Nebraska 16.28 and Oklahoma 20.08 inches. Colorado had only 10.68 inches, somewhat less than the previous driest year of record, 1934, in which only 10.89 inches fell. The average for Wyoming was 9.48 inches, also somewhat lower than the previous driest year, 9.81 inches in 1902. The California average of 15.85 inches was the least since 1932.

Tornadoes, duststorms, and other outstanding features of the weather of 1939 are discussed elsewhere in this issue of the REVIEW.

TABLE 1.—*Monthly and Annual Temperature Departures from Normal for the Year 1939*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Ala.	+4.6	+4.7	+3.6	−0.9	−0.3	+0.8	+0.6	−1.1	+1.6	+2.2	−2.0	+2.2	+1.3
Ariz.	+.2	−8.9	−.3	+2.3	+1.6	−.2	+1.1	+.7	−.7	−1.4	+2.5	+4.8	+.1
Ark.	+4.1	.0	+2.7	−2.1	+.2	+.7	+1.5	+.1	+5.4	+2.7	−2.5	+2.7	+1.3
Calif.	−.1	−5.5	−1.1	+2.7	+.3	−1.1	−.7	+.8	+1.4	−.3	+1.2	+3.5	+.1
Colo.	+1.9	−7.9	+1.0	+2.3	+3.6	+.8	+2.5	+.9	+3.6	+1.1	+2.5	+6.6	+1.6
Fla.	+1.6	+5.6	+2.8	+.8	−.7	+.5	.0	−1.3	+.9	+1.6	−2.1	−.5	+.8
Ga.	+2.4	+5.5	+2.4	−.6	−1.1	+1.4	+.4	−1.2	+1.4	+2.0	−1.9	+.9	+1.0
Idaho	+3.7	−5.3	+1.1	+2.7	+3.1	−2.6	+.7	+1.3	+1.4	+.3	+2.8	+7.8	+1.4
Ill.	+6.6	+.7	+2.6	−2.7	+3.4	+1.5	+.2	−1.0	+4.5	+2.4	−.2	+4.7	+1.9
Ind.	+5.4	+1.7	+2.2	−3.0	+2.9	+2.1	−.5	+.3	+4.7	+2.8	−1.3	+3.2	+1.7
Iowa	+10.1	−2.0	+1.8	−.9	+6.3	+1.8	+1.6	−1.5	+5.4	+1.8	+3.6	+8.3	+3.0
Kans.	+8.4	−2.6	+2.1	−.2	+4.6	+1.5	+4.3	+.2	+5.7	+3.9	+1.1	+5.9	+2.9
Ky.	+4.4	+3.2	+3.0	−2.5	+.9	+1.2	−.6	−.5	+3.9	+2.7	−2.8	+1.1	+1.2
La.	+3.5	+2.5	+2.0	−1.0	−.4	+.6	+.9	+.1	+1.9	+1.3	−2.2	+3.0	+1.0
Md.-Del.	+1.4	+6.0	+1.8	−.5	+2.6	+2.7	−1.4	+3.0	+1.5	+1.1	−1.6	+2.4	+1.6
Mich.	+3.0	+.4	−.9	−2.2	+3.5	+2.3	+1.5	+2.4	+1.9	+.1	+.1	+5.8	+1.5
Minn.	+5.9	−7.1	−1.4	−2.6	+5.5	+.7	+1.6	+1.2	+4.2	−1.5	+5.8	+10.7	+1.9
Miss.	+3.0	+2.7	+2.8	−1.9	−.3	+.7	+.9	−.2	+2.9	+1.7	−2.9	+1.8	+.9
Mo.	+8.0	−.1	+3.1	−1.8	+2.9	+1.0	+2.0	−1.1	+6.1	+3.6	−.9	+4.6	+2.3
Mont.	+8.9	−6.2	+2.1	+2.7	+3.8	−4.0	+2.1	+1.2	+2.4	+.3	+5.7	+8.7	+2.3
Nebr.	+8.9	−4.6	+3.2	+.3	+6.6	+.9	+4.7	+.3	+5.2	+2.0	+3.4	+7.7	+3.2
Nev.	+3.0	−5.8	+2.2	+4.0	+3.5	+.4	+1.5	+2.7	+1.7	+.6	+3.1	+7.9	+2.1
N. England	−.8	+2.7	−4.5	−3.4	+.1	−.1	+.2	+3.8	−.5	.0	−3.1	+.5	−.4
N. J.	.0	+5.8	+1.0	−1.4	+2.9	+2.0	−.3	+3.5	+.6	+.2	−2.1	+1.5	+1.1
N. Mex.	−.3	−8.2	+.6	+1.3	+1.2	+.9	+.2	−.2	+1.8	−.8	−.5	+3.9	.0
N. Y.	+.2	+4.1	−2.2	−2.5	+2.5	+1.0	+.4	+4.0	−.9	.0	−3.0	+1.4	+.4
N. C.	+1.9	+5.7	+3.1	+.1	−.4	+3.2	−.6	.0	+1.8	+2.7	−3.0	−.3	+1.2
N. Dak.	+8.7	−10.2	−.5	+.2	+6.5	−2.4	+3.7	+2.1	+2.1	−2.5	+8.2	+13.7	+2.5
Ohio	+4.8	+3.4	+1.9	−2.6	+3.2	+3.0	−.8	+1.0	+4.4	+2.6	−1.1	+3.3	+1.9
Okla.	+5.9	−2.1	+3.4	−.5	+3.1	+1.4	+2.5	+.7	+5.7	+4.1	−1.3	+5.3	+2.4
Oreg.	+3.0	−2.9	+1.4	+3.0	+2.3	−2.2	+1.1	+1.5	+2.1	+.1	+.8	+5.8	+1.3
Pa.	+1.8	+5.3	+.9	−1.9	+3.2	+1.8	−.5	+3.0	+1.7	+1.0	−1.6	+2.6	+1.4
S. C.	+2.3	+5.8	+3.1	+.1	−1.1	+3.1	+.2	−.4	+1.8	+2.8	−3.4	+.2	+1.2
S. Dak.	+8.9	−7.9	+2.6	+.3	+7.8	−.1	+4.4	+1.0	+3.9	+.1	+5.8	+10.0	+3.1
Tenn.	+3.5	+3.4	+2.7	−2.0	+.1	+1.6	+.7	−.2	+3.7	+3.2	−2.7	+1.5	+1.3
Tex.	+2.7	−2.8	+2.2	+.5	+2.2	+1.2	+1.4	−.5	+2.3	+1.8	−3.0	+3.5	+1.0
Utah	+1.4	−9.6	+.8	+3.6	+2.7	−.5	+.7	+1.2	+1.1	+.5	+3.2	+7.3	+1.0
Va.	+2.6	+5.9	+2.0	−.6	+1.3	+3.1	−1.3	−.9	+1.7	+1.5	−2.4	+1.5	+1.2
Wash.	+5.8	−2.2	+.5	+2.4	+1.9	−2.0	+.9	+2.0	+2.1	+.6	+2.9	+6.5	+1.8
W. Va.	+3.6	+5.6	+2.4	−1.8	+1.8	+3.0	−1.1	+.9	+2.3	+1.3	−2.4	+2.0	+1.5
Wis.	+6.8	−2.6	−.7	−2.8	+4.3	+1.2	+1.4	+1.0	+2.1	.0	+2.3	+8.3	+1.8
Wyo.	+4.0	−8.0	+2.4	+3.5	+4.3	−2.2	+2.0	−.5	+2.1	+1.2	+3.4	+8.0	+1.7

TABLE 2.—*Percentage of Normal Precipitation, 1939*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Ala.	99	194	87	82	139	146	89	233	119	14	26	67	108
Ariz.	84	94	65	88	12	11	51	103	335	55	136	29	89
Ark.	145	258	78	146	96	110	88	68	53	55	91	58	104
Calif.	67	54	81	32	99	38	114	70	370	87	17	65	91
Colo.	171	112	88	51	54	59	41	55	83	50	32	51	71
Fla.	59	73	50	151	124	138	105	153	85	71	62	78	96
Ga.	92	187	91	101	119	106	84	137	78	12	30	78	93
Idaho	81	121	74	50	49	107	113	27	98	101	16	122	80
Ill.	137	156	109	148	58	126	103	141	20	79	48	50	98
Ind.	133	172	106	166	38	160	125	78	25	100	47	45	100
Iowa	80	162	103	76	51	114	84	133	22	62	31	52	81
Kans.	118	121	119	76	62	115	43	111	11	30	63	95	80
Ky.	127	232	123	153	34	143	117	77	43	78	33	59	102
La.	116	124	60	52	146	95	97	96	83	66	88	77	92
Md.-Del.	111	169	114	144	32	167	93	116	78	125	51	58	105
Mich.	119	160	81	107	74	158	58	169	81	94	33	70	100
Minn.	163	193	51	70	73	127	71	122	49	83	5	52	88
Miss.	136	166	96	80	125	163	92	66	100	44	41	77	99
Mo.	123	158	97	129	87	117	77	123	29	65	99	71	97
Mont.	74	107	73	70	90	143	49	57	71	81	23	110	79
Nebr.	127	121	110	57	72	102	55	72	21	42	5	100	74
Nev.	81	77	97	101	83	39	167	67	327	193	46	43	110
N. England	78	107	122	137	53	98	61	103	76	134	31	94	91
N. J.	111	154	128	142	38	96	49	148	42	124	58	42	94
N. Mex.	248	86	101	99	63	52	96	71	114	79	94	94	100
N. Y.	98	140	105	113	48	85	60	76	93	107	53	99	90
N. C.	109	191	90	99	69	93	132	126	36	66	72	66	96
N. Dak.	100	137	51	60	66	134	72	101	43	71	5	54	74
Ohio	92	166	121	160	34	173	109	60	70	118	35	53	99
Okla.	191	124	86	72	79	139	55	89	11	57	71	64	86
Oreg.	76	114	81	22	61	87	109	83	53	105	14	146	79
Pa.	97	150	104	108	41	107	73	71	85	119	34	71	88
S. C.	87	207	89	103	95	86	105	129	53	27	46	76	92
S. Dak.	173	118	31	48	78	118	71	84	61	88	1	51	77
Tenn.	128	225	93	111	81	141	87	79	44	44	44	72	96
Tex.	161	100	50	48	85	98	99	91	38	54	88	73	82
Utah	115	105	68	66	70	116	61	63	261	119	15	37	91
Va.	106	169	85	95	74	109	139	127	37	108	90	62	100
Wash.	116	121	74	38	76	104	129	57	46	88	50	139	86
W. Va.	99	183	107	153	34	143	127	84	76	117	35	74	100
Wis.	157	180	57	90	76	134	57	111	72	75	19	64	88
Wyo.	100	112	58	60	74	106	62	71	81	73	1	55	71

PRELIMINARY REPORT ON TORNADOES IN THE UNITED STATES DURING 1939

BY R. J. MARTIN

[Weather Bureau, Washington, D. C., February 1940]

A preliminary report on the tornadoes which occurred within the United States during 1939 is here included in the December REVIEW, as has been the custom in recent years. A more detailed study will appear in the Meteorological Yearbook for 1939 which will be issued the latter part of 1940 or early in 1941. Practically all of the information contained in the present summary has been abstracted from the monthly REVIEW table of "Severe Local Storms" compiled from the reports of many observers and the various Section Directors of the Bureau. It must be remembered that all the statistics presented in this preliminary report are subject to change in the detailed study.

One hundred and thirty-eight tornadoes were reported during the year, with a death toll of 98, and property losses of more than $5,226,230. April, with 42 tornadoes and 58 fatalities, was the month with the greatest number of storms and largest loss of life. Approximately 30 percent of the year's tornadoes and over 59 percent of the total deaths occurred in this month, although property damage was exceeded by both June and August losses.

The spring season, March, April, and May, had 69 tornadoes, or exactly 50 percent of the year's total. Summer (June, July, and August) had 47 tornadoes, or about 34 percent. Tornado deaths during the Spring amounted to 69, or over 70 percent of the year's casualties. Tornadoes occurred without loss of life in July and October. No tornadoes were reported in November and December.

Arkansas, with 35 fatalities, was the State reporting the greatest number of deaths from tornadoes during the year. Texas was second with 12, Louisiana and Minnesota tied for third place with 10 deaths each. Oklahoma reported 7 fatalities, Tennessee and North Carolina 5 each, Florida 4, Alabama 3, Michigan 2, and New York, Virginia, South

Carolina, Georgia, and South Dakota one each. Nonfatal tornadoes occurred in Kansas, Iowa, Missouri, Illinois, Indiana, Pennsylvania, and New Jersey.

Michigan had the greatest tornado damage, with losses estimated at $1,725,000. Minnesota was second with damage amounting to $1,345,000, and Texas third with $543,800. In Virginia, North Carolina, South Carolina, Illinois, Louisiana, Arkansas, and Iowa losses exceeded $100,000, while in South Dakota, Kansas, Oklahoma, Missouri, Indiana, Tennessee, Mississippi, Alabama, Georgia, Florida, Pennsylvania, and New York losses varied from $10,000 for Pennsylvania to $92,050 for Kansas. No estimate of damage was obtained for the single tornado which occurred in New Jersey in April.

The preliminary estimate of total damage is only 67 percent of the preliminary figure for 1938 and is less than half the normal annual tornado damage, the normal being based on a 22-year period, 1916–37, inclusive. The total number of storms, 138, is only 3 less than the usual annual number, but the loss of life was only 55 percent of the 1938 total and about 37 percent of the normal annual death toll from tornadoes.

The most severe storm of the year in respect to fatalities was the one of April 16, which covered a path 15 miles long and 440 yards wide in Arkansas, causing 27 deaths, injuries to 62 persons, but property losses of only $20,000.

A storm in Florida in March caused 4 deaths, one in Louisiana in April caused 8, and one in Minnesota in June resulted in 9 fatalities. North Carolina had 4 deaths from one storm in February, and Oklahoma 7 deaths from one storm in April. Four of the 6 deaths in January resulted from a single storm in Tennessee.

The storms causing the greatest property damage occurred in Michigan and Minnesota. A storm in Kalamazoo, Mich., on August 8 caused losses of $1,050,000 and brought death to two persons. Other tornadoes in the same State on that date caused property damage amounting to $675,000. On June 18, a tornado in Minnesota resulted in 9 deaths and property losses of $1,300,000.

A total of 13 storms with some tornadic characteristics (some of these may have been tornadoes) were experienced during the year. These were mostly confined to February and August, and resulted in 4 deaths and property damage of over $1,435,000. In Illinois 3 deaths and losses of $1,000,000 occurred when tornadic winds visited western and central portions of the State on August 10, and one death and losses of $100,000 were reported in Cattaraugus County, N. Y., on September 29.

TORNADOES AND PROBABLE TORNADOES

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Number	4	13	12	42	15	26	7	14	3	2	0	0	138
Deaths	6	7	6	58	5	11	0	4	1	0	0	0	98
Damage [1]	54	287	262	553	377	1,610	70	1,947	6	60	0	0	[2] 5,226

TORNADIC WINDS AND POSSIBLE TORNADOES [3]

Number	0	5	0	0	0	1	1	5	1	0	0	0	13
Deaths	0	0	0	0	0	0	0	3	1	0	0	0	4
Damage [1]	0	310	0	0	0	5	4	1,016	100	0	0	0	[2] 1,435

[1] In thousands of dollars.
[2] Damage occurred in addition to amount shown.
[3] Some of these may not be classed as tornadoes in the final study.

DUSTSTORMS OF 1939 IN THE UNITED STATES

By R. J. MARTIN

[Weather Bureau, Washington, D. C., February 1940]

Duststorms of 1939 were not so widespread or destructive as in several previous years, although occasional storms, particularly in western areas, were locally as severe as any experienced since 1930. A few eastern districts noted dusty conditions, the dust usually being confined to the upper atmosphere, or falling mixed with rain or snow. The 1939 storms were not as numerous as in several recent years.

The storms of 1939 are here discussed by months, the descriptions, in most instances, being based on reports submitted by field officials of the Weather Bureau. At times these reports have been included almost verbatim in this summary.

January.—Despite continued dry conditions in much of the Winter Wheat Belt, with lack of moisture most acute in Oklahoma and Kansas and parts of Texas, Missouri, and Iowa, duststorms were mostly light in character and limited in extent during the month.

Considering the country as a whole, storms were most extensive on the 4th–6th. Geographically the most northern report of dust came from Havre, Mont., where light dust occurred on the 19th, and the farthest eastward was at Sault Ste. Marie, Mich., where light dust mixed with rain, or rain and snow, was reported on the 5th and 15th.

Storms in the central and southern Great Plains were most general between the 4th and 6th and after the 16th. The "Dust Bowl" had 3 to 5 days with pronounced soil blowing. At Dodge City, Kans., thick dust reduced visibility to less than 1 mile on the 27th and 31st, and as far south as Port Arthur, Tex., duststorms with reduced visibility continued for as long as 9 hours. At San Antonio, Tex., the storm on the 5th continued for 14 hours and at Abilene the storm lasted from early in the morning of the 5th to the night of the 6th. At Port Arthur and El Paso minimum visibilities were 2½ miles; at Abilene 1½ miles.

In South Dakota fresh to brisk winds were reported in all sections on the 14th and from the 21st to the 25th, with local dust blowing noted from McPherson westward to Carson County and from Dewey and Stanley Counties westward to Butte and Mead Counties from the 21st to the 25th.

In Colorado northwesterly winds on the 4th raised considerable dust in extreme eastern counties south of the Arkansas-Platte Divide, especially south of the Arkansas River. Shallow-rooted weeds were loosened and blown away, exposing loose and friable soil to erosion over large areas. In northeastern Baca County the visibility was reduced to zero for several hours in the lee of blowing fields. Strong northerly winds on the 22nd, 23rd, 25th, and 27th did slight damage to fields in Baca County. Dust reduced visibility to from 2,000 to 5,000 feet.

On the 31st, strong winds which continued for about 7 hours caused light to moderate dust in Lincoln, Kit Carson, Cheyenne, Kiowa, and Prowers Counties and considerable erosion occurred in Baca County where new areas began to blow. Thin stands of sorghum stalks failed to prevent blowing, and wheat, unprotected by strips of heavy sorghum growth, was generally blown out.

In parts of Baca County the visibility was reduced to from zero to 100 feet for a period of from 5 to 7 hours. This was the most destructive duststorm to date for the winter of 1938–39 in Colorado.

Heavy dust was noted over much of northwestern and extreme southwestern Oklahoma on the 4th with a visibility of ⅛ mile reported at Hollis, 200 yards at Canton for a short period, and ¼ mile at Goodwell.

Another heavy duststorm covered much of northwestern Oklahoma on the 27th with visibilities of less than one mile at Alta, Goodwell, Waynoka, Hooker, and Mutual; at Goodwell the visibility was less than ¼ of a mile for over 4 hours. Goodwell and Hooker, both in the panhandle, had heavy dust on the 31st with a minimum visibility of 200 yards at 3:30 p. m.

February.—Duststorms were more widespread in February than during the preceding month and were reported on the 28th as far east as central Tennessee and central Indiana, northward to southwestern Minnesota and portions of South Dakota, and southward to the Texas coast. The most easterly occurrence of dust was at Scranton, Pa., on the 20th.

In the Great Plains, duststorms were most frequent during the first decade and the last 3 or 4 days of the month. A few reports of moderate to heavy dust were received, chiefly from the central and southern Great Plains.

A Soil Conservation Service report from Amarillo, Tex., stated that the "Dust Bowl" had shrunk to less than ⅓ of its original size, with portions of Texas, New Mexico, Kansas, Colorado, and Oklahoma in the best condition since 1932. The "Bowl" had been reduced from an area of approximately 50,000,000 acres at its worst in the winter of 1935–36 to only 9,500,000 acres on February 1st, according to H. H. Finnell, Regional Conservator; in parts of the "Bowl" area the soil was wet to a depth of 48 inches.

At Goodwell, Okla., light storms were reported on the 4th, 9th, 12th, 13th, 15th, 16th, and 18th. At times visibility was reduced to less than 1 mile; this was the case on the 9th with a minimum visibility of one-fourth mile and on the 16th of one-half mile. At Cheyenne a visibility of 200 yards was reported on the 7th and at Elk City and Goodwell on the 9th it was reduced to one-fourth mile. Heavy dust was also noticed at Tipton on the 16th, while on the 27th heavy dust covered the central and southern portions of the State, reducing visibility at times to three-fourths mile at Pauls Valley and Altus, one-fourth mile at Tipton, and one-fourth mile at Duncan. Light dust was reported at one or more Oklahoma stations on 15 days, though no damage was reported, except for a small amount of wheat blown out in northwestern sections.

Four to six duststorms occurred in extreme southwestern counties of Kansas. On the 18th they were reported in a number of localities scattered over the western third of the State, and on the 19th were general over the western third and extended to some central counties. Light to moderate dust was carried in the upper air into eastern counties on several days, including the 7th, 8th, and 19th.

Southeastern Nebraska had a duststorm on the 7th which began before noon in Hall County, about 1 p. m. in Nuckolls, and at 2:30 p. m. in Lancaster County; the lowest visibility at Lincoln was 500 feet, but the storm was of short duration.

High northerly and northwesterly winds raised considerable dust in Baca County, Colo., on the 16th, resulting in moderate damage to fields, and reducing visibility to 50 feet in the lee of fields for several hours. On the 18th and 19th strong southwesterly winds were erosive in Baca County with visibilities of 50 to 500 feet for periods of from 5 to 8 hours on each of the 2 days. These were the most destructive storms reported in the State. Light to moderate dust was noted on the 18th as far north as Prowers, Cheyenne, Kit Carson, and Elbert Counties.

Light to moderate storms were reported in Texas, particularly in the Panhandle, on from 1 to 6 days. The storms were heavy at Amarillo on the 9th and 16th with minimum visibility of one-half mile for 3 hours; the maximum wind velocity during the storm of the 9th was 56 miles per hour. Dust reduced visibility to less than 1 mile in Houston for several hours on the 10–11th.

March.—Duststorms became more serious during March with parts of Oklahoma, the Texas Panhandle, and Kansas again seriously affected. The worst duststorm in 2 years brought heavy clouds of red dust to an area of about 100,000 square miles in six States, including portions of New Mexico, Arkansas, Missouri, Kansas, Oklahoma, and Texas. Light dust was reported from Montana eastward to Sault Ste. Marie, Mich., and from New Mexico eastward to Alabama.

Storms were most frequent from the 11th to the 19th, though a few were reported, especially in the northern Great Plains and upper Mississippi Valley, during the last decade. The number of days with dusty conditions varied from 2 or 3 in the extreme northern Great Plains to as many as 9 in portions of Texas. Dense or heavy dust occurred on 1 to 2 days in portions of southern Missouri, western Oklahoma, and the Texas Panhandle.

At El Paso, Tex., dust was reported at elevations exceeding 8,000 feet and continued in the upper atmosphere from the 15th through the 19th. The minimum visibility noted at Abilene was one-fourth mile on the 11th, but at Springfield, Mo., the worst duststorm in 3 years reduced horizontal visibility to one-fifth mile and ceiling to zero for about 1½ hours. At Amarillo, Tex., the visibility was zero for 1 hour on the 4th and for 5 hours on the 11th. On the 5th and 14th visibility was reduced to one-half mile for from 1 to 2 hours; the maximum wind velocity reported during the storms was 60 miles per hour on the 11th.

At Oklahoma City, Okla., the heaviest storm of local record reduced visibility to 400 feet and deposited heavy coatings of fine dust even in weather-stripped houses. At the Oklahoma City airport the visibility was reduced to zero. Light dust was noted in some parts of the State from the 3rd to the 11th, inclusive, and on the 18–19th, and heavy dust at one or more stations on the 4th, 11th, 14th, and 23d. The storm of the 11th covered practically the entire State, reducing visibility to from 10 to 30 yards at some stations. Some wheat was blown out on sandy lands, but the aggregate damage was not large.

In New Mexico strong winds on the 4th and 5th caused heavy blowing dust in east-central and southwestern counties, and on the 10th visibility was zero most of the day over south-central and southwestern districts. On the 11th visibility ranged from zero to 3 miles in much of the eastern part of the State, and on the 14th and 15th dust was noted from the Rio Grande Valley to the eastern border. The top of the dust cloud was reported at 12,000 feet.

Duststorms were reported in extreme southwestern Kansas on the 11th, 14th, 18th, and 23d; on the 11th the dust reached as far east and north as Dodge City. Only light dust was reported in Montana, principally on the 11th, 25th, and 31st in Hill, Liberty, Chouteau, and Fergus Counties. Light dust was reported in various

parts of Illinois on 4 days, and at some widely scattered points in Indiana on 7 days.

April.—Dusty conditions were reported at only a few stations east of the Mississippi River during April. There were four occurrences of light dust in southwestern Illinois, on the 1st, 9th, 18th, and 22d, and dust was reported at two stations in Indiana on the 10th and in Tennessee on the 18th.

Extreme western Minnesota noted dusty conditions on the 4th, 11th, 20th, 25th, and 26th, and dust was noted aloft at Kansas City, Mo., on the 11th.

In the tiers of States reaching from Montana and the Dakotas southward to Texas and Oklahoma dusty conditions were rather frequent, although no real duststorms were reported in several of these States. Light local dust was noted in eastern Nebraska on the 10th, and in the western part of the State on the 16th, and dusty conditions prevailed in southwestern New Mexico on 5 days between the 10th and 21st. In Kansas, Oklahoma, and Texas storms were rather frequent, though they were mostly light. As many as 16 days with dusty conditions were reported in southwestern Kansas, 9 or 10 days in northern and central Texas, and 8 in Oklahoma.

A duststorm was general throughout northern and western North Dakota on the 17th with visibility as low as 1½ miles during part of the afternoon. In South Dakota wind velocities ranging from 27 to 43 miles per hour resulted in local soil blowing, in some instances the worst since 1935, in the eastern two-thirds of the State from the 3d to the 10th, on the 16th–17th, and the 24th–26th. On April 24 the visibility at Huron was reduced to one-tenth mile.

Duststorms in Kansas were confined to the western third of the State, except on the 10th when storms were reported in Edwards and Sumner Counties. In the extreme southwest county, Morton, duststorms occurred on 16 days. Storms were reported at several localities in the southwest quarter on the 9th, 10th, 16th, 17th, 22d, 23d, and 24th. Dusty conditions occurred on several days in the northwestern part of the State with storms noted in Decatur County on the 23d and 24th.

In Oklahoma light dust was noted at one or more stations on the 9th, 10th, 14th, and 16th–24th; heavy dust was confined to the panhandle and extreme western tier of counties. At Goodwell the visibility was 100 yards at 1 p. m. on the 17th, one-fourth to one-half mile for 4 hours on the 18th, and 1 mile on the 20th. On the 20th, 24th, and 30th visibility at that station was again cut to one-fourth mile. A heavy duststorm on the 10th reduced visibility decidedly.

In Colorado winds of moderate to gale force were frequent during the month and considerable dust was carried aloft in extreme southeastern counties on the 9th, 10th, 12th, 13th, 14th, 16th, 17th, 20th, and 23d. The duration of dust movement averaged about 7 hours on these days with visibility reduced to from 200 feet to zero at times in the lee of blowing fields. Moderate to severe erosion occurred in Baca County on all these dates, except the 12th and 20th; the storm of the 16th continued until the 17th, causing much erosion locally and killing or damaging young seeds in all blowing areas.

Duststorms were reported in various portions of Montana on 13 days; they were particularly widespread on the 15th and 19th, especially in northern portions of the State.

May.—Dust was reported in May as far east as Massachusetts where Harvard's Blue Hill Observatory recorded the most intense duststorm in 5 years over Massachusetts and New Hamsphire. Visibility was diminished to 5 miles at the observatory and sunshine was reduced by 50 percent.

Light to moderately heavy dust was observed in most sections of Michigan on the 10th, though horizontal visibility was not greatly reduced. Most of the stations reporting dust were located in the north-central portion of the Lower Peninsula; the minimum visibility was 2 miles at Milford.

In Wisconsin light dust appeared in the northwest on the afternoon of the 9th and spread over the remainder of the State during the night so that dust was quite generally reported in the morning of the 10th. The dust disappeared in the northern portions during the forenoon, but persisted until late afternoon of the 10th in the southeast.

Northern and west-central Illinois reported dusty conditions on the 10th and 22nd; dense dust was noted at Mount Carroll on the 10th. Light dust was reported on as many as 9 days, well scattered throughout the month, in western Minnesota, and light dust was observed in western Missouri on the 6th and 10th.

In the States from Montana and the Dakotas southward dusty conditions were reported on from 1 to as many as 16 days. In North Dakota duststorms were reported at many stations on the 5th, 7th, 8th, 9th, 17th, 19th, and 20th. At Bismarck a storm on the 9th reduced visibility to one half mile from 10 to 11:30 p. m., while on the 19th–20th visibility was less than 1 mile from 9:30 p. m. of the 19th to 12:30 a. m. of the 20th. In South Dakota dust was noted throughout the State from the 5th to 10th and in the western two-thirds on the 17th and 20th.

Strong winds, with local dust blowing, were reported at a number of stations in the eastern half of Nebraska on the 6th and light dust was noted in the upper air in all but the extreme western part of the State on the 10th; at times in many localities the dust was thick enough to justify the term "duststorm." On the 24th local dust blowing was reported at a few stations in south-central and southwestern portions of the State. At Valentine visibility on the 9th was cut to one-half mile or less.

In Kansas duststorms were general in southwestern counties on the 5th, 6th, and 24th. In Morton, the extreme southwest county, duststorms occurred on 16 days and in Grant County on 6. Dust of more or less intensity was raised in most parts of the State on 1 or more days, but the only storms reported outside the southwestern counties were at Plainville on the 5th and Oberlin on the 6th.

Heavy dust was noted at Kenton, Cimarron County, Okla., on the 6th, 20th, and 24th. Visibility was about 100 yards for a time on the 6th while on the other 2 dates the minimum was about 1 mile. At Coalgate a 50-yard visibility prevailed for a time on the 19th. Light dust was noted at one or more stations on the 5th, 6th, 10th, 11th, 17th, 22d, and 23d; the storm on the 6th was the most extensive and was felt from Erick and Waynoka eastward to Bartlesville and Tulsa and southward to Duncan.

In northwestern Texas duststorms occurred on the 18th and 20th. In Amarillo the storm of the 10th resulted in a visibility of one-half mile for a period of 2 hours, while the one on the 20th cut visibility to three-fourths mile for 1 hour.

On the 9th a heavy pall of dust hanging over Montana limited visibility in several cities. Air transportation was not seriously affected, for although horizontal visibility was poor near the ground, planes topped the dust cloud at from 8,000 to 9,000 feet above sea level, airline officials said.

Other duststorms prevailed in Montana on the 5th and 19th; at Miles City in both these storms visibility was 100 feet for short periods of time. At Havre dusty conditions, at times approaching the intensity of a duststorm, were reported on the 3rd, 4th, 6th, 8th, 9th, and 20th. On the 8th–11th dense clouds of dust which had been whipped into the air by strong winds in extreme north-central Montana overspread the northern tier of counties east of the Continental Divide to Blaine County and southward to Cascade. The dust had overspread and settled in all sections of Montana east of the Divide by the evening of the 9th with horizontal visibility generally as low as 1 mile. On the afternoon of the 19th severe duststorms occurred in Yellowstone, Beacon, Rosebud, Custer, Garfield, McCone, and Valley Counties.

In Colorado considerable damage was suffered as a result of frequent "dusters" in southeastern counties. On the 5th, 6th, 10th, 11th, 15th, 19th, 20th, and 24th duststorms were general in eastern counties. Heavy erosion was confined mostly to barren ground, except where soil from such ground was carried to adjoining fields of small and tender plants which were either cut off by sabulous winds or completely covered by the blowing sand and soil. A storm on the 23d covered almost the entire State; it continued throughout most of the day and dust was so thick at times that visibility was only 100 feet.

June.—During June light dust was noted as far east as portions of Michigan where south-central stations experienced dusty conditions on the 16th. In southwestern Illinois light dust was observed on the 5th, and two stations recorded dusty conditions in the northern part of the State on the 7th, and in south-central Illinois on the 11th.

Thick dust was reported on the 4th at Tracy, Lyon County, Minn. Many cornfields were damaged, some being stripped completely. Light dust was reported in extreme western portions of the State on the 4th and 7th.

In the tiers of States from Montana and South Dakota southward duststorms were rather frequent. In portions of Kansas dusty conditions were reported on from 10 to as many as 18 days. In South Dakota local dust blowing was experienced in the southern half on the 4th and 5th, in south-central sections on the 14th, in the southeast quarter on the 17th, and in a large part of the western half of the State on the 27th. In Nebraska dust blowing was reported in Antelope, Pierce, and Knox Counties on the 4th of the month.

At Dodge City, Kans., light dust, with visibility ranging from five-eighths to 6 miles, occurred on the 9th, 14th–18th, 20th–21st, 25th, 26th, and 29th, a total of 11 days; on the 21st visibility was cut to less than five-eighths of a mile. In southwestern counties of the State the most general storms were experienced on the 9th–10th, 14th–17th, 20th, 28th, and 29th. In northwestern counties the storms were less frequent and more limited in extent; they were reported in this area on the 11th, 16th, 19th, and 20th. A few storms occurred in central parts of the State, and moderate dust was reported in the middle third and some eastern counties on one or two dates.

Heavy dust was confined to the extreme northwestern portion of Oklahoma. At Kenton a severe "black blizzard" arrived at 8 p. m. on the 9th and continued until after midnight; visibility was nearly zero at times during this storm, and some crop deterioration resulted. Waynoka reported heavy dust on the 17th–18th, and light dust was noted at one or more stations on the 3d, 4th, 6th, 9th–11th, 13th–18th, and 21st. Dust was confined to the western third of the State.

In the south Plains sections light dust was most frequent in western portions of Texas; at El Paso light dust was noted on 9 days, although visibility was only slightly affected. At Abilene dusty conditions obtained on the 10th, and at Amarillo dust reduced visibility to zero for 1 hour on the 10th and to one-half mile for an hour on the 19th.

Moving northward to Montana we find that local dust blowing occurred in portions of Flathead County on the 22d, in Stillwater, Yellowstone, and Big Horn Counties on the 23d, and in Chouteau and Gallatin Counties on the 30th.

Following 2 months of deficient precipitation, strong dessicating winds in June resulted in destruction of many crops and damaged the topsoil over large areas in Colorado. Duststorms were more frequent and damaging than at any other time during the year. A report from H. F. Choun describes the duststorms during June and is appended herewith:

Moderate to severe dust began in Baca County on the 3d and southerly winds spread the dust throughout extreme eastern counties east of the one hundred and third meridian on the 4th and 5th. In this region, brisk winds distributed considerable dust from 6 a. m. to 6 p. m., reducing the visibility to 100 feet for 12 hours in Baca County and to 2 to 3 miles as far north as Kit Carson County.

Slight damage was caused to fields by a moderate intermittent duster in Baca County on the 6th.

During the late afternoon of the 9th, strong northerly winds disturbed the topsoil throughout eastern counties, reducing the visibility to a quarter mile in Arapahoe and Kit Carson Counties, to one-half mile in Elbert and Lincoln Counties, and to zero in Baca County where a very severe black duster continued through the night. The duster moved into Pueblo with a northwest wind of 34 miles per hour velocity about 6 p. m. At the height of the storm, visibility was reduced to 1 mile on the prairies adjacent to the city. All travel by air was grounded for a short time and highway travel was much impeded due to poor visibility. The only damage reported in the Pueblo area was to small trees and shrubbery. Young corn, sugar beets, and bean plants in the Greeley area were cut off at the ground by blowing sand, and dust darkened the sky during most of the afternoon. Heavy dust sifted over Denver and reduced the visibility to zero at the Municipal Airport where the wind attained a velocity of 56 miles per hour.

Strong northerly and northwesterly winds caused violent dust clouds in Prowers and Baca Counties during the early evening and night of the 10th, reducing the visibility to 50 feet at times and causing some damage to vegetation.

On the 11th, northerly and northwesterly winds reduced the visibility to one-half mile to 1 mile in Douglas, Elbert, and northern El Paso Counties, and strong southerly winds caused a severe duststorm of short duration in Baca and parts of Prowers Counties.

On the 15th, southerly winds of gale force extended throughout the State and dust of varying intensity was reported from all sections. In extreme southeastern counties the storm was intense for 4 hours, reducing the visibility to 50 feet. In east-central counties severe dust prevailed from 4 p. m. to 8 p. m. while high dust clouds were seen or dust settled over practically every county in the State. In the Dolores Valley and the San Juan Mountain region, southerly winds arising on the Navajo Indian Reservation and adjoining localities in Utah, Arizona, and New Mexico, brought the most severe duststorms that that section ever experienced. Visibility was reduced in places to a quarter mile and crops were damaged considerably.

Scattered showers, after the middle of the month, relieved appreciably the drought situation, and duststorms were confined to extreme southeastern counties on the 16th, 17th, 20th, 21st, 24th, and 25th. The visibility was reduced to 50 feet to 500 feet on each of these days and living conditions were rendered uncomfortable for an average of 5 hours each day.

July.—During July duststorms were noted as far east as New York State. On Staten Island parching heat for 27 days baked the moisture from the soil on truck farms and tons of dust were swept over residential areas. No other reports of dusty conditions were received during the month from stations east of the Mississippi River.

In western districts duststorms were mostly confined to Plains sections from Oklahoma northward to South Dakota, and to portions of Colorado and Montana. In

Colorado hot, drying winds were frequent in eastern Plains districts and in extreme southeastern counties duststorms of damaging intensity occurred on the 8th, 15th, 17th, 22d, and 24th. Soil erosion on these dates was mostly caused by southerly winds, and visibility was reduced from 200 to 500 feet for 1 to 4 hours. Light to moderate storms causing no material damage or discomfort were reported from northeastern counties of the State on numerous dates.

Dusty conditions were reported at Kansas City, Mo., on the 11th, 12th, and 18th; the storm of the 18th, of very short duration, reduced visibility to about one-half mile.

At Huron, S. Dak., dusty conditions were reported on the 2d, 19th–21st, and 31st, and local dust blowing was noted in all sections of the State on the 4th, in the western third on the 15th, and again in all sections of the State on the 20th, 27th, 29th, and 30th. Nebraska enjoyed an almost dustless month, although at Valentine storms of short duration were experienced on the 16th and 18th. In both of these storms visibilities were limited for short periods of time, although the dust in both instances was of purely local origin.

In Kansas two snow plows were kept available for clearing dust from the tracks of the Santa Fe line between Dodge City and Boise, Okla. At Dodge City duststorms sufficiently heavy materially to limit visibility were reported on the 1st, 4th, 7th, 16th, 17th, 19th, 22d, 24th, and 26th, while for the State as a whole duststorms, mostly of local origin, were rather frequent on from 4 to 9 days. No severe storms were reported in the middle or eastern third of the State, though light dust occurred there on several days.

The only heavy dust reported in Oklahoma was at Waynoka on the 22d, with visibility reduced to three-fourths of a mile for a short period. Light dust was noted at Goodwell on the 6th and 31st, and at Kenton on the 7th, 15th, and 21st.

In the northern Great Plains, Montana experienced dusty conditions on about 4 days, mostly during the first half of the month. Minimum visibilities were one-half mile at Havre on the 2d, and one-fifth mile at the same station on the 10th. In Hill, McCone, Lewis and Clark, Custer, and Gallatin Counties the dust was mostly of local origin.

August.—During August duststorms were confined to portions of the Great Plains and southern Rocky Mountain region. In Oklahoma heavy dust was noted at Clinton, Garber, and Hennessey on the 7th, with a 10-yard visibility reported at Hennessey and 100 yards at Garber. Light dust was noted at Enid on the 4th and 7th, at Waukomis on the 22d, and Clinton on the 14th, while Kenton reported dust on the 7th, Okeene on the 11th, and Waynoka on the 22d and 31st.

Local dust blowing was noted in Harding County, S. Dak., on the 18th of the month and in the eastern third of the State on the following date. Light dust was reported at Huron on the 19th, 21st, and 27th.

In Kansas 6 to 9 duststorms occurred in extreme southwestern districts and a few storms of rather local nature occurred elsewhere in the western part of the State on 1 or 2 days, mostly the 22d and 30th.

In northwestern Texas and eastern New Mexico a few duststorms were reported near the end of the month with the lowest visibility at Amarillo, Tex., 1½ miles on the 22d. In Montana storms, mostly light and local in character, were reported on as many as 11 days. The storm at Trident, Gallatin County, on the 4th, was classed as severe, while the storm of the 3d at Helena diminished surface visibility at times to about one city block.

September.—During September duststorms were again reported in several States east of the Mississippi River. Dusty conditions prevailed in Indiana and Tennessee on the 29th, but in the latter State the storm was of very short duration.

Light dust was observed in extreme western Minnesota on the 5th, 14th, and 24th, and at several Montana stations on the 1st, 11th, and 24th. In Oklahoma, although the month was the driest September of record, duststorms were relatively few and were confined to the western half of the State. These storms were mostly light in character and were most general in extreme northwestern sections on the first 3 days of the month or after the 16th. The worst and most general storm occurred on the 29th; at two stations this storm was classified as heavy and visibility was reduced to 1 mile or less for nearly 2 hours.

In Kansas duststorms were reported in extreme southwestern counties on from 5 to 8 days. On the 3d storms of limited extent were reported in many western counties and locally in the eastern part of the State, while on the 28th and 29th duststorms were rather general in much of western third. At Dodge City light dust was observed on 9 days, mostly during the first half of the month. Visibility was reduced to one-half mile or less during the storm of the 29th.

In Nebraska coarse sand and dust reduced visibility to less than 1 mile for about an hour at Valentine on the 22d. Light to thick dust, but not severe in any locality, was observed over most of the State on the 3d, 12th, and 13th, and over scattered areas on the 5th, 6th, 11th, 14th, 22d, 24th, 27th, and 28th.

In South Dakota local dust blowing was quite prevalent in the eastern third on the 5th, and in the eastern half on the 21st and 24th.

A few storms, mostly light in character, were noted in Texas on the 29th and 30th. Some of these were sufficient to reduce visibility to as little as 1 mile for several hours.

October.—During October dusty conditions were noted in Montana on 5 days, mostly after the 19th, and in extreme southwestern Minnesota on the 3d, 15th, and 31st. In South Dakota local dust blowing was prevalent in the eastern third on the 1st, 2d, and 4th, and in scattered places throughout the State on the 21st, 29th, and 31st. Further south, in Nebraska, light to moderate dust was observed over the entire State, especially in the Panhandle on the 1st and 2d, and locally on other dates.

Kansas reported duststorms in extreme southwestern counties on from 4 to 8 days. They were most common on the 1st, 4th, 7th, and 26–28th. The storms of the 1st and 4th were most general and were observed as far east as Rush County. Texas and New Mexico reported dusty conditions early in the month and again during the closing days, while in Montana storms were most general on the 19th–21st, 24th, and 29th.

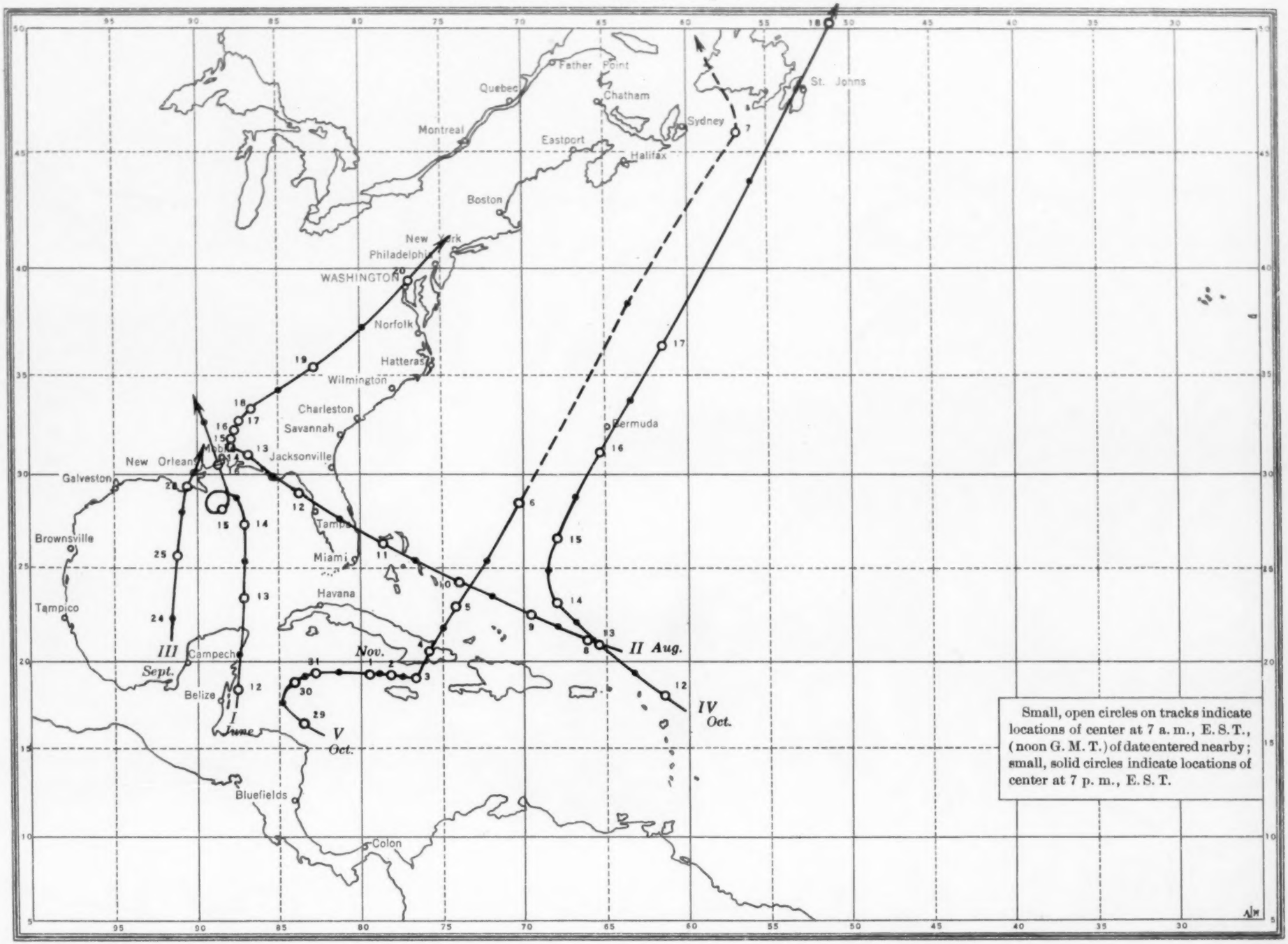
Only a few duststorms were reported in Oklahoma and these were generally light in character. The most widespread storm in this State was noted on the 29th.

November.—Duststorms during November were confined to the Great Plains, except for isolated occurrences in extreme northwestern portions of Minnesota on the 9th and 10th, and a few central sections of Wisconsin on the 9th.

In South Dakota soil blowing occurred locally in the eastern third on the 4th and 9th, and quite generally in all sections on the 23d and 27th; at Huron dusty conditions prevailed for comparatively short periods of time on the 4th, 9th, 23d, 27th, and 28th.

No storms were reported in Nebraska, but in southwestern Kansas thick dust of a local nature was reported on 2 or 3 days while on the 9th light dust was felt in many

Paths of Hurricanes and Other Tropical Storms of 1939



parts of the State. Oklahoma noted light dust in the Panhandle on the 9th.

In Montana light dust was reported on the 2d, 8th, 22d, 29th, and 30th. The storms of the 22d in north-central counties were the most extensive.

December.—During December duststorms were reported from Montana eastward to portions of Illinois and southward to Texas. In Illinois light dust was observed on the 12th–13th, 14th, and 28th. The storms were all light in character, and of short duration.

In the upper Mississippi Valley light storms were reported in Minnesota on the 11th, 12th, and 16th, while in Iowa a heavy duststorm carried by a 40-mile wind resulted in sharply reduced visibilities and considerable discomfort. Light dust was observed in western Missouri on the 1st, 2d, and 12th.

South Dakota, because of deficient moisture and high winds, experienced soil blowing in all sections on the 1st, 11th–12th, and 15th–16th. In Nebraska a severe duststorm occurred at Valentine on the 12th, with lowest visibility about one-fourth mile for about one-half hour.

In Kansas dusty conditions were observed on the 1st, 11th, 12th, and 18th, and on the same days dust was reported in western Oklahoma with visibility reduced to less than 1 mile in the panhandle sections on 2 or more days. Light dust was reported in Texas on the 1st, 2d, 3d, 12th, 18th, and 19th, and in Montana, particularly in northern districts, on the 6th, 11th, 14th, and 15th.

NORTH ATLANTIC TROPICAL CYCLONES OF 1939

By WILLIS E. HURD

Five tropical cyclones occurred in the North Atlantic Ocean, including the Gulf of Mexico and the Caribbean Sea, during the hurricane season of 1939. A synopsis of some of their more important features is given in the table herewith. Their tracks, numbered I to V chronologically, are shown on the accompanying chart. The average annual number of tropical cyclones occurring during the past 53 years is about 7, 1939 thus showing a deficiency of 2.

In 1939 there was only one major hurricane, that of October 12–18 (IV). This expended its energy at sea, but passed so close to Bermuda in its north-northeastward course as to be damaging to the islands. Another storm, that of October 29–November 8 (V), may be classed as a hurricane, although winds of full hurricane force were reported on only 1 day, October 30, while crossing Grand Cayman Island. A week later, in higher latitudes, one ship reported a gale of force 11. The other 3 cyclones had known locally highest winds not in excess of force 9 or 10. In chronological occurrence, there was 1 tropical cyclone each in June, August, September, and October, and 1 in October–November.

The hurricane of October 12–18 was the only one of the 5 disturbances to attain great barometric depth. On the 14th its lowest reported minimum was 941.4 millibars (27.80 inches), but on the 17th and 18th pressures were noted almost down to 948 millibars (28 inches). Two of the cyclones were shallow, and lowest barometers did not fall as low as 999 millibars (29.50 inches).

Of the cyclones, 2 (I and III) were associated almost wholly with the Gulf of Mexico; 1 (V) originated in the Caribbean Sea, where it remained for a week, then crossed eastern Cuba and, so far as can be determined from meager ship's reports in the western Atlantic, held to a northeastward course as far as Newfoundland; 2 (II and IV) originated over or in the vicinity of the Leeward Islands, 1 keeping a northwesterly course across Florida, then recurving up the eastern United States, the other remaining at sea until it crossed southeastern Newfoundland.

Two storms of the year took abnormal directions during a part of their tracks. That of June (I), described a rare left-handed loop in the northern part of the Gulf of Mexico; that of October–November (V) performed an unusual curve from northwesterly through north into easterly then northeasterly while in tropical waters.

Only 5 or 6 lives are known to have been lost directly or indirectly due to these tropical cyclones. Economically, the year's losses from them were comparatively small. No estimates of property losses are available for the three storms (II, IV, and V) that caused some damage. (See under "Remarks" in the table.)

North Atlantic tropical cyclones of 1939

[Synopsis of tropical cyclones of 1939 (number of storm in table corresponds to number of track on accompanying chart)]

Storm	Date	Place where first reported	Coast lines crossed	Maximum wind velocity reported	Lowest barometer reported	Place of dissipation	Intensity	Remarks
I	June 12-16.	Gulf of Honduras.	Yucatan, Alabama.	Force 9, southeast S. S. *Alabama.*	1,000.3 millibars (29.54 inches) S. S. *Kefrei.*	Tennessee	Not of hurricane intensity.	1 person drowned (A).
II	Aug. 8-20.	Northeast of Puerto Rico.	Florida, Alabama.	Force 10, east, S. S. *Pan Amaco;* 62 miles Tampa Airport.	988.5 millibars (29.19 inches) St. Andrews, Fla.	Southeastern New York.	do	1 person drowned. Some damage from wind, heavy rains and floods (B).
III	Sept. 24-26.[1]	Northwest of Yucatan.	Louisiana	Force 9, north-northeast, M. S. *Cubahama.*	1,003.7 millibars (29.64 inches) M. S. *Cubahama.*	Mississippi and Alabama.	do	(C.)
IV	Oct. 12-18.[2]	Leeward Islands.	None	Force 12, by several ships and by Bermuda.	941.4 millibars (27.80 inches) S. S. *F. W. Abrams.*	East of Newfoundland.	Intense hurricane	Some damage at Bermuda and to ships at sea; 1 life lost at sea (D).
V	Oct. 29-Nov. 8.[3]	Western Caribbean Sea.	Cuba, Newfoundland.	92 miles at Grand Cayman Island.	989.0 millibars (29.21 inches) ship at sea.	East of Labrador.	Hurricane on 1 day; of force 11 on 2 others.	Definite loss of 2 lives; property damage in the Cayman Islands Jamaica, and Cuba; 4 schooners lost in the Caymans (E).

Complete reports of these cyclones may be found in the MONTHLY WEATHER REVIEW: (A) June 1939: 67: 175, 176. (B) August 1939; 67: 296, 297. (C) September 1939; 67: 340. (D) October 1939: 67: 382, 383. (E) November 1939; 67: 416.

[1] There was squally weather in the extreme southwestern part of the Gulf of Mexico on the 22d to early 24th, and unsettled weather in the northwestern Caribbean on the 23d, but no definite cyclonic circulation could be charted until 7 p. m. (eastern standard time) of the 24th.

[2] Unsettled weather and slightly depressed barometer occurred to the eastward of the Antilles as early as the 9th, but no cyclonic center could be established prior to the 12th.

[3] Disturbed weather occurred in the southwestern Caribbean on October 27, but no cyclonic circulation was defined until the 29th. The dashed part of track V indicates that the course of the storm is approximated, due to lack of ship reports. Late information received from the meteorological office, Kingston, Jamaica, shows that, on November 2, at 7 a. m., Negril Point had a barometer of 1,000 millibars (29.53 inches), with a west-northwest wind of 60 miles, and heavy sea; at 9 a. m. Kempshot had a barometer of 992.6 millibars (29.31 inches), with a wind velocity of about 70 miles from southwest.

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SOLAR OBSERVATIONS

[Meteorological Research Division, EDGAR W. WOOLARD in charge]

SOLAR RADIATION OBSERVATIONS, DECEMBER 1939

By IRVING F. HAND

Measurements of solar radiant energy received at the surface of the earth are made at nine stations maintained by the Weather Bureau, and at ten cooperating stations maintained by other institutions. The intensity of the total radiation from sun and sky on a horizontal surface is continuously recorded (from sunrise to sunset) at all these stations by self-registering instruments; pyrheliometric measurements of the intensity of direct solar radiation at normal incidence are made at frequent intervals on clear days at three Weather Bureau stations (Washington, D. C., Madison, Wis., Lincoln, Nebr.) and at the Blue Hill Observatory of Harvard University. Occasional observations of sky polarization are taken at the Weather Bureau stations at Washington and Madison.

The geographic coordinates of the stations, and descriptions of the instrumental equipment, station exposures, and methods of observation, together with summaries of the data, obtained up to the end of 1936, will be found in the MONTHLY WEATHER REVIEW, December 1937, pp. 415 to 441; further descriptions of instruments and methods are given in Weather Bureau Circular Q.

Table 1 contains the measurements of the intensity of direct solar radiation at normal incidence, with means and their departures from normal (means based on less than 3 values are in parentheses). At Madison and Lincoln the observations are made with the Marvin pyrheliometer; at Washington and Blue Hill they are obtained with a recording thermopile, checked by observations with a Marvin pyrheliometer at Washington and with a Smithsonian silver disk pyrheliometer at Blue Hill. The table also gives vapor pressures at 7:30 a. m. and at 1:30 (75th meridian time).

Table 2 contains the average amounts of radiation received daily on a horizontal surface from both sun and sky during each week, then departures from normal and the accumulated departures since the beginning of the year. The values at most of the stations are obtained from the records of the Eppley pyrheliometer recording on either a microammeter or a potentiometer.

Direct radiation intensities averaged close to normal at all four stations.

Total solar and sky radiation was above normal at every station during December. With the exception of Twin Falls, Riverside, and Miami, all stations showed an excess in total solar and sky radiation during the entire year; the excess being particularly marked at Washington, Madison, and Chicago.

Polarization observations made at Madison on 4 days give a mean of 69 percent with a maximum of 73 percent on the 8th. These are close to normal for December.

The normal incidence reading of 0.048 gram calorie (corrected for mean solar distance), made at 5.0 air mass on the afternoon of December 12, 1939, at Lincoln, is the lowest ever recorded by this bureau through any of the standard air masses. K. W. Kemper's original notations on the record sheets for this day read, "Sky very dusty. Visibility fair. Brisk northwest wind. No clouds."

With no clouds present, the depletion of radiation cannot be attributed to condensed water-vapor, while the "fair visibility" clearly indicates that most of the dust was above the observer, or at an elevation of more than 100 feet above ground. The brisk northwest wind proves that this duststorm was general rather than local.

Figure 1 shows the relationship between the actual observed normal incidence radiation on the afternoon of December 12 and the 25-year normals for the same air masses.

This severe dust cloud gives added verification of the extreme drought conditions which prevailed in the mid-West during 1939.

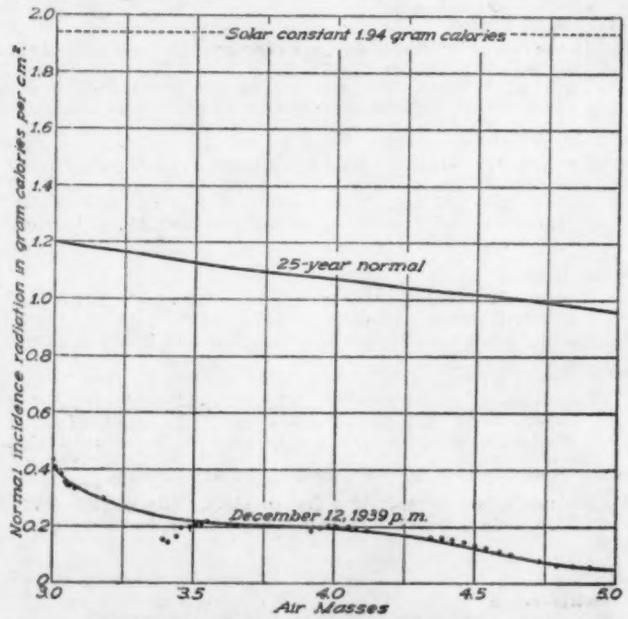


FIGURE 1.—Plot of normal-incidence readings made on the afternoon of December 12, 1939, at Lincoln, Nebr., showing the effect of the duststorm.

TABLE 1.—*Solar radiation intensities during December 1939*

[Gram-calories per minute per square centimeter of normal surface]

WASHINGTON, D. C.

Date	Sun's zenith distance: 7:30 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	1.30 p. m.
	75th mer. time	Air mass: A. M.					P. M.				75th mer. time
	e	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Dec. 8	2.74	0.90	1.06	1.24	1.41						2.49
Dec. 22	2.06			1.17							2.26
Means		(.90)	(1.06)	(1.20)	(1.41)						
Departures		+.11	+.15	+.15	+.17						

MADISON, WIS.

Dec. 6	4.17	1.10	1.24	1.42		1.68		1.37			4.95
Dec. 7	4.17	.91	1.15	1.48							4.17
Dec. 8	3.45	1.13	1.32								3.15
Dec. 14	1.52							1.19			2.36
Dec. 22	1.52		1.18	1.10				.75			3.00
Means		1.05	1.22	1.33				1.10			
Departures		+.07	+.12	+.11				−.12			

LINCOLN, NEBR.

Dec. 1	5.56	0.92	1.22								4.57
Dec. 2	2.49	1.21	1.31	1.42							2.49
Dec. 4	4.17			1.27							3.99
Dec. 5	3.30							1.22	1.07		3.99
Dec. 6	2.87	1.10	1.19	1.30				1.33	1.15	0.99	3.30
Dec. 7	3.63							1.28	1.14	1.06	3.99
Dec. 8	3.15	.91	1.03	1.20				1.14	.98	.84	4.57
Dec. 9	3.99	.89	1.02	1.19							4.17

[1] Extrapolated.

TABLE 1.—*Solar radiation intensities during December 1939*—Con.

[Gram-calories per minute per square centimeter of normal surface]

LINCOLN, NEBR.—Continued

Date	Sun's zenith distance: 7:30 a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	1.30 p. m.
	75th mer. time	Air mass: A. M.					P. M.				75th mer. time
	e	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	e
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Dec. 12	2.16							.46	.20	.05	1.78
Dec. 14	2.06								.96	.83	3.15
Dec. 15	2.49							1.25	1.08	.93	3.30
Dec. 19	2.87	1.17	1.26	1.37					1.23	1.09	2.62
Dec. 20	2.26	1.08	1.22	1.36							2.62
Dec. 21	2.16							1.21	1.09	.94	2.36
Dec. 22	1.45	.72	.90	1.06				1.11			2.16
Dec. 29	.51							1.06	.91	.80	1.32
Means		1.00	1.13	1.27				1.12	.98	.84	
Departures		+.04	+.03	+.03				−.08	−.08	−.11	

BLUE HILL, MASS.

Dec. 1	3.0	0.67	0.82	0.97	1.21						4.2
Dec. 4	4.0	.72	.80	.95	1.05						3.8
Dec. 8	3.3							1.16	1.04	.92	2.8
Dec 12	1.5						1.22	1.03	.88	.82	2.2
Dec 15	1.5	.97	1.06	1.16	1.27	1.40		1.28	1.10	1.08	1.5
Dec. 16	2.9	.65	.76	.87	1.02						4.4
Dec. 19	3.3	.67	.80	.94							3.6
Dec. 23	1.7	1.05	1.18	1.28	1.46		1.44	1.30	1.17	1.06	1.5
Dec. 24	1.5	1.05	1.18	1.28	1.48		1.39	1.27	1.19	1.10	1.5
Dec. 25	1.9	1.04	1.14						1.12	1.04	1.5
Dec. 26	1.1	1.10	1.19	1.30	1.40		1.44	1.29	1.16	1.06	1.1
Dec. 28	.7	1.22	1.32	1.42	1.53		1.39	1.23	1.12	1.00	.7
Means		.81	1.02	1.13	1.30	1.40	1.38	1.22	1.10	1.01	
Departures		−.05	−.02	−.05	−.04		+.09	+.08	+.07	+.06	

TABLE 2.—*Average daily totals of solar radiation (direct + diffuse) received on a horizontal surface*

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Fairbanks	Twin Falls	La Jolla	Miami	New Orleans	Riverside	Blue Hill	San Juan	Newport
	Gram calories per square centimeter														
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Dec. 3	209	151	210	128	109	192	12	119	259	334	273	220	132	484	130
Dec. 10	160	138	192	96	120	185	7	126	265	316	283	247	132	444	139
Dec. 17	159	114	171	89	95	151	8	127	252	320	221	234	131	402	133
Dec. 24 [1]	176	123	141	93	130	186	6	113	305	287	219	240	169	431	148
	Departures from weekly normals														
Dec. 3	+50	+35	+35	+56	+5	+8	+3	+4	+11	+24	+19	+7	+3		+9
Dec. 10	+20	+24	+26	+14	+15	+14	+1	+8	+30	+12	+62	+44	−1		−22
Dec. 17	+15	−5	−6	+3	−1	−1	+2	+9	+8	+34	+2	−3	0		+13
Dec. 24 [1]	+26	+1	−34	+8	+15	+39	−1	−18	+69	+2	+57	+27	+19		+5
	Accumulated departures on—														
	+18,387	+12,734	+7,876	+19,601	+8,420	+1,222	+1,420	−2,678	+4,717	−5,934		−4,003	+3,757		+3,176
	Percentage departures for the year														
	+14.8	+10.7	+5.7	+19.5	+8.2	+0.7	+1.8	−1.9	+3.2	−4.0		−2.6	+3.0		+2.4

[1] Eight-day means.

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellwez, U. S. Navy (Ret.) Superintendent, U. S. Naval Observatory. Data from measurements at the U. S. Naval Observatory from plates obtained at the observatories indicated. Difference in longitude is measured from the central meridian, positive toward the west. Latitude is positive toward the north. Areas are corrected for foreshortening and expressed in millionths of Sun's hemisphere. For each day below longitude, latitude, area of spot or groups, and spot count, are given respectively the assumed longitude of the center of the disk, assumed latitude of the center of the disk, total area of spots and groups, and total spot count]

Date	Eastern standard time	Mount Wilson group No.	Heliographic				Area of spot or group	Spot count	Plate quality	Observatory
			Difference in longitude	Longitude	Latitude	Distance from center of disk				
1939	h. m.		°	°	°	°				
Dec. 1	12 17	6692	−78	140	−10	79	145	1	G	Mt. Wilson.
		6697	+34	262	−7	33	873	25		
		6684	+38	256	−2	39	61	2		
		6682	+59	277	−12	60	61	1		
		6691	+62	280	−20	64	48	3		
				(218)	(+1)		1, 188	34		
3	11 11	6692	−51	142	−9	52	73	1	G	Do.
		6694	+55	248	+4	55	24	2		
		6687	+57	250	−7	58	170	13		
		6687	+65	258	−9	65	339	4		
		6693	+65	258	+6	65	48	3		
		6684	+65	258	−2	65	73	2		
		6682	+88	281	−12	88	48	1		
				(193)	(+1)		775	26		
4	11 30	6692	−38	141	−10	40	121	3	G	U. S. Naval.
		6695	−6	173	+17	17	12	4		
		6694	+66	245	+5	66	24	1		
		6687	+68	247	−7	69	121	6		
		6687	+77	256	−9	78	291	1		
		6684	+77	256	−2	77	73	1		
				(179)	(+1)		642	16		
5	10 55	6692	−24	142	−10	26	73	1	G	Do.
		6696	+8	174	−16	18	24	2		
		6695	+8	174	+17	19	24	3		
				(166)	(0)		121	6		
6	11 8	6692	−11	142	−10	15	97	1	VG	Do.
		6697	−10	143	−15	17	48	3		
		6696	+21	174	−16	28	12	2		
				(153)	(0)		157	6		
7	10 34	6698	−45	95	−18	49	6	1	G	Do.
		6692	+2	142	−10	11	97	1		
		6697	+2	142	−14	15	73	6		
		6693	+6	146	−10	13	24	11		
				(140)	(0)		200	19		
8	11 1	6709	−79	48	+7	79	12	1	G	Do.
		6699	−75	52	−7	76	97	3		
		6697	+16	143	−14	20	121	4		
		6692	+16	143	−10	18	73	1		
		6692	+20	147	−11	23	48	5		
				(127)	(0)		331	14		
9	10 35	6700	−65	49	+7	65	48	2	G	Do.
		6699	−61	53	−7	62	73	2		
		6701	−59	55	−16	60	145	5		
		6692	+29	143	−10	30	73	2		
		6697	+30	144	−14	33	121	4		
		6692	+34	148	−11	35	48	5		
				(114)	(0)		508	20		
10	11 44	6702	−80	20	+30	80	242	1	G	Do.
		6700	−49	51	+7	50	24	1		
		6699	−43	52	−7	49	73	5		
		6701	−45	55	−16	47	242	11		
		6692	+43	143	−10	44	48	1		
		6697	+46	146	−14	48	73	5		
		6692	+49	149	−11	50	24	3		
				(100)	(0)		726	37		
11	10 49	6704	−79	8	+23	78	12	1	VG	Do.
		6702	−67	20	+30	81	291	2		
		6703	−50	37	−16	52	6	3		
		6700	−37	50	+7	38	12	1		
		6699	−36	51	−7	37	73	7		
		6701	−35	52	−16	37	24	11		
		6701	−29	58	−16	33	218	1		
		6692	+57	144	−10	57	24	1		
		6697	+62	149	−14	63	36	1		
		6692	+63	150	−11	63	12	1		
				(87)	(0)		708	29		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic				Area of spot or group	Spot count	Plate quality	Observatory
			Difference in longitude	Longitude	Latitude	Distance from center of disk				
1939	h. m.		°	°	°	°				
Dec. 12	11 7	6705	−75	359	+15	77	6	1	VG	Do.
		6704	−66	8	+23	70	145	9		
		6702	−53	21	+30	60	364	3		
		6700	−23	51	+8	24	12	1		
		6699	−22	52	−7	23	85	9		
		6701	−22	52	−17	27	48	5		
		6701	−15	59	−16	22	218	1		
		6692	+70	144	−10	73	24	1		
		6697	+75	149	−14	75	24	1		
				(74)	(−1)		926	31		
13	11 27	6707	−73	346	−7	75	48	2	VG	Mt. Wilson.
		6705	−60	1	+15	62	61	5		
		6704	−52	9	+23	58	121	13		
		6702	−40	21	+30	50	339	17		
		6706	−27	34	+8	27	12	2		
		6703	−21	40	−17	26	12	2		
		6699	−7	54	−7	10	36	6		
		6701	−2	59	−17	16	194	2		
		6692	+83	146	−11	85	6	1		
				(61)	(−1)		829	50		
14	13 17	6707	−6[illegible]	347	−7	60	12	1	VG	U. S. Naval.
		6705	−4[illegible]	0	+15	50	24	6		
		6704	−3[illegible]	10	+23	43	48	12		
		6702	−2[illegible]	20	+30	41	194	6		
		6706	−1[illegible]	35	+9	15	61	10		
		6708	+[illegible]	49	−16	16	24	4		
		6701	+[illegible]	54	−16	17	12	2		
		6699	+[illegible]	56	−8	12	48	7		
		6701	+14	61	−15	20	218	1		
				(47)	(−1)		641	49		
15	11 45	6710	−30	4	−13	33	24	1	VG	Do.
		6704	−24	10	+23	34	145	17		
		6702	−14	20	+30	33	218	1		
		6706	+3	37	+8	10	48	10		
		6701	+21	55	−15	25	12	2		
		6699	+22	56	−8	22	24	3		
		6701	+28	62	−15	31	242	6		
				(34)	(−1)		713	40		
16	11 21	6705	−20	1	+16	25	12	1	VG	Mt. Wilson.
		6704	−11	10	+22	23	339	30		
		(*)	−7	14	−25	25	6	1		
		6709	−3	18	−15	13	48	9		
		6702	−1	20	+29	30	218	7		
		6706	+18	39	+8	21	12	1		
		6699	+36	57	−8	28	61	1		
		6701	+41	62	−16	44	194	6		
				(21)	(−1)		890	56		
17	11 45	6712	−81	287	−19	82	6	2	F	U. S. Naval
		6711	−70	298	+14	72	6	1		
		6704	+3	11	+22	23	201	16		
		6709	+11	19	−15	18	48	4		
		6702	+12	20	+30	33	194	1		
		6699	+50	58	−8	50	24	1		
		6701	+56	64	−15	57	121	1		
				(8)	(−1)		690	26		
18	10 28	6712	−68	287	−19	69	97	4	G	Do.
		6704	+15	10	+22	26	339	27		
		6702	+24	19	+30	37	194	1		
		6709	+28	23	−15	32	6	1		
		6706	+39	34	+8	40	24	2		
		6699	+62	57	−8	62	12	1		
		6701	+69	64	−15	69	121	1		
				(355)	(−1)		793	37		
19	10 45	6712	−54	288	−19	56	85	1	G	Do.
		6714	−1	341	−17	16	12	1		
		6713	+7	349	−20	20	6	1		
		6704	+28	10	+22	35	436	30		
		6702	+38	20	+30	48	194	1		
		6701	+81	63	−15	82	12	1		
				(342)	(−1)		745	35		
20	15 36	6716	−88	238	−11	88	97	1	P	Do.
		6715	−72	254	−9	72	97	2		
		6715	−71	255	−11	71	194	3		
		6712	−38	288	−18	41	48	4		
		6713	+22	348	−19	27	6	1		
		6704	+40	6	+22	45	97	11		
		6704	+50	16	+21	54	242	9		
		6702	+51	17	+29	58	194	2		
				(326)	(−2)		975	33		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1939	h. m.		°	°	°	°				
Dec. 21	10 50	6716	−74	242	−11	75	97	2	VG	Mt. Wilson.
		6715	−61	255	−9	62	73	2		
		6715	−59	257	−11	60	194	7		
		6712	−28	288	−18	33	48	7		
		6704	+52	8	+22	56	73	3		
		6704	+60	16	+21	63	242	9		
		6702	+62	18	+29	67	194	4		
				(316)	(−2)		921	34		
22	11 6	6716	−60	242	−11	60	194	3	G	U. S. Naval.
		6715	−48	254	−9	49	73	1		
		6715	−45	257	−11	46	194	2		
		6712	−14	288	−19	23	24	1		
		6704	+75	17	+22	78	145	2		
		6702	+76	18	+29	80	145	1		
				(302)	(−2)		775	10		
23	11 53	6716	−46	243	−11	47	194	2	F	Do.
		6715	−35	254	−10	36	97	3		
		6715	−31	258	−12	33	170	8		
		6712	−1	288	−19	18	24	1		
				(289)	(−2)		485	14		
24	11 32	6718	−48	228	−21	51	24	4	G	Do.
		6716	−31	245	−11	32	194	1		
		6715	−21	255	−10	23	97	6		
		6715	−19	257	−11	21	145	9		
		6717	−12	264	−10	14	24	5		
		6712	+12	288	−19	21	24	1		
				(276)	(−2)		508	26		
25	13 3	6718	−35	227	−21	40	6	2	F	Mt. Wilson
		6716	−18	244	−11	22	170	4		
		6715	−7	255	−10	11	73	8		
		6715	−5	257	−11	11	97	7		
		6717	+8	270	−8	10	6	1		
		6719	+25	287	+12	27	6	1		
				(262)	(−2)		358	23		
26	11 39	6718	−20	229	−21	28	36	4	VG	U. S. Naval
		6716	−3	246	−11	10	170	1		
		6715	+4	253	−10	10	24	5		
		6715	+9	258	−11	13	145	9		
				(249)	(−2)		375	19		
27	11 31	6718	−7	229	−21	19	6	1	G	Mt. Wilson
		6716	+9	245	−11	12	109	6		
		6715	+22	258	−11	23	97	13		
		6719	+52	288	+12	53	18	4		
				(236)	(−2)		230	24		
28	13 56	6721	−66	156	−16	67	6	2	F	Do.
		6720	−20	202	+19	29	48	6		
		6716	+24	246	−11	26	109	5		
		6715	+35	257	−10	35	97	11		
		6719	+66	288	+13	67	12	5		
				(222)	(−3)		272	29		
29	13 15	6723	−83	126	+16	82	97	1	G	Do.
		6720	−6	203	+19	22	36	7		
		6716	+37	246	−11	36	109	4		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1939	h. m.		°	°	°	°				
Dec. 29	13 15	6715	+48	257	−10	48	48	9		
		6722	+55	264	+6	56	12	1		
		6719	+78	287	+12	78	12	1		
				(209)	(−3)		314	23		
30	11 54	6723	−69	128	+16	70	194	6	VG	U. S. Naval.
		6724	−65	132	+9	65	48	4		
		6720	+6	203	+19	22	24	4		
		6716	+40	246	−11	40	109	4		
		6715	+60	257	−10	60	12	2		
				(197)	(−3)		387	20		
31	12 4	6725	−66	117	+12	67	12	1	G	Do.
		6723	−54	129	+17	56	194	2		
		6724	−50	133	+9	51	36	4		
		(*)	+22	205	−11	22	6	1		
		6716	+63	246	−12	62	97	4		
		6715	+75	258	−10	75	12	1		
				(183)	(−3)		357	13		

Mean daily area for 30 days=585.

*=not numbered.
VG=very good; G=good; F=fair; P=poor.

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR DECEMBER 1939

[Dependent alone on observations at Zurich]

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich, Switzerland]

December 1939	Relative numbers	December 1939	Relative numbers	December 1939	Relative numbers
1	*d* 54	11		21	*d* 46
2	40	12		22	47
3	43	13	*a* --	23	* 35
4		14		24	
5		15		25	**a* 32
6	*Mc* --	16	*a* 53	26	**a* 37
7	*a* 23	17	*ad* 52	27	
8	*d* 47	18	* 61	28	
9		19	*d* 44	29	
10	*d* --	20		30	*d* 46
				31	34

Mean, 16 days=43.4.

*Observed at Chur.
a=Passage of an average-sized group through the central meridian.
b=Passage of a large group through the central meridian.
c=New formation of a group developing into a middle-sized or large center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central-circle zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE in charge]

By B. FRANCIS DASHIELL

Observations of pressures, temperatures and humidities made in the upper air by radiosondes, airplanes and pilot balloons during December are given in tables 1, 2, and 3. The pressures and temperatures, as well as resultant-wind directions and velocities, for 1.5, 3, 4, and 5 kilometers, are shown on charts VIII, IX, X and XI, respectively. Table 4 indicates the average heights of the tropauses, and chart XII presents the December isentropic data. Effective December 1, the United States Navy discontinued airplane observations at Pensacola, Fla., and substituted the use of radiosondes.

The distribution of mean pressure at 5,000 feet was such that the lowest pressure prevailed over the northeastern portion of the United States and the highest over Florida. Pressures reduced to this level showed the lowest to be at Mount Washington, N. H. (828.0 millibars), while the highest occurred in the southern Rocky Mountain region (Durango, Colo., 852.6 millibars). In the upper levels low mean pressure persisted over Sault Ste. Marie, Mich., with the highest over Pensacola and Miami, Fla. Outside the United States proper, the lowest pressures at all levels prevailed over Alaska, with Fairbanks consist-

ently about 10 millibars lower than Juneau at each corresponding level.

The mean barometric pressures during the current month were lower than those for November. Such was the case over all stations at every level, and, in many instances, December pressures were lower than any noted since radiosonde observations were inaugurated. It was also found that the current month showed pressures lower than in December 1938 at all levels over Washington, D. C., and in all but the higher altitudes over Nashville, Tenn., and Sault Ste. Marie, Mich. At Omaha, Nebr., however, the current month showed higher mean pressures for all levels than during the corresponding month of 1938.

Pressure differences between the high and low pressure areas, indicated by Miami, Fla., and Sault Ste. Marie, Mich., were greatest at 7 and 8 kilometers by as much as 30 millibars. This gradient, although associated with moderately high winds at identical levels, failed to coincide with the region of highest resultant winds and maximum individual velocities occurring at 9, 10, and 11 kilometers as shown in tables 2 and 3, respectively.

Mean free-air temperatures for the month were lowest over Sault Ste. Marie, Mich., and highest over the South, and particularly Miami, Fla., at 1.5, 3, 4, and 5 kilometers, as shown on charts VIII, IX, X, and XI, respectively. At these levels, as well as those up to 8 kilometers, the temperature difference between the points of extreme means (Miami, Fla., and Sault Ste. Marie, Mich.), remained uniform at approximately 18° C. Then the difference decreased with additional altitude until, at 11.4 kilometers, temperatures over both stations were equal. But above this level mean temperatures over Sault Ste. Marie, Mich., became warmer than those over Miami, Fla., with the difference increasing with altitude to 18° C. at 16 kilometers.

December temperatures were lower than those noted during the preceding month up to 16 kilometers, and then warmer above. In Alaska, however, the means at Juneau and Fairbanks showed the current month to be warmer at all levels. All stations having 1 year of radiosonde records showed that the current December was warmer than in December 1938 at all levels below 10 kilometers. At Omaha, Nebr., however, the current month was warmer at all levels, while Washington, D. C., showed means lower than in December 1938 above 2 kilometers.

The lowest individual temperature recorded during December was −78.1° C. at 15 kilometers over Miami, Fla. Other outstanding low readings were made at 17 kilometers in the Southwest. Mean and individual minimum temperatures were highest over Fairbanks, Alaska.

Resultant winds are shown on charts VIII, IX, X, and XI, for 1.5, 3, 4, and 5 kilometers, respectively. At 1.5 kilometers, winds from the northwest quadrant predominated east of the Rocky Mountains, while southwesterly and southeasterly directions occurred over the far West. This circulation, about the high pressure area in the Rocky Mountain region, still persisted to a slight extent at 3 and 4 kilometers. However, northwesterly directions practically covered the entire country, and at 8 and 10 kilometers (see table 2) northwesterly winds existed everywhere, with the exception of Miami, Fla.

Resultant velocities were high over most of the United States, except in the far Southwest at 1.5 and 3 kilometers. While a similar distribution was maintained at all higher levels, there was an increase in velocity with altitude. Outstanding resultant velocities occurred over the lower Great Lakes region, the Ohio Valley, and the Middle Atlantic States, with the highest for the country at 1.5 kilometers being recorded at Kylertown, Pa. (12.7 meters per second); at 3 kilometers over Cincinnati, Ohio (16.2 meters per second); at 4 kilometers over Chicago, Ill. (22.5 meters per second); at 5 and 8 kilometers over Richmond, Va. (25.2 and 35.8 meters per second); and at 10 kilometers over Huron, S. Dak. (28.8 meters per second).

Except in the far Northwest, at 3 and 5 kilometers, and west of the Rocky Mountains at 4 kilometers, the resultant wind directions departed from normal by turning in clockwise rotations. However, these departures were not large, except for a few scattered instances where velocities were comparatively low. Resultant velocities were greater than normal at each level over practically every station, but departures were not excessive below 5 kilometers. At the latter level, however, large positive departures from normal were noted at Billings, Mont., Cheyenne, Wyo., and Atlanta, Ga. (+11.1, +7.7 and +7.2 meters per second, repectively.).

Table 2 shows resultant winds based on 5 p. m. (seventy-fifth meridian time) observations. These directions, when compared with those for 1.5 and 3 kilometers based on 5 a. m. observations, showed a decided diurnal tendency to become more northerly over all but the southern and western portions of the United States. Elsewhere, the directions were more southerly in the afternoon. The 5 p. m. velocities were less than in the early morning over all of the country except along the northern border at 1.5 kilometers, and over the entire Rocky Mountain region at 3 kilometers.

The maximum wind velocities for December are given in table 3. The velocity of 87.5 meters per second (195.8 miles per hour) over Omaha, Nebr., at 12 kilometers on the 22d, is the highest of record in that section of the country, and is the fourth highest ever to be recorded by means of pilot balloons.

MONTHLY MEAN ISENTROPIC CHART [1]

The monthly mean isentropic chart, $\theta=300°$, for December 1939 (chart XII) shows that the westerlies had pushed southward over the eastern part of the country practically to the Gulf Coast, while an anticyclonic eddy is suggested in the moisture pattern over the Southwest, although not in the resultant wind circulation. With no knowledge of the normal isentropic pattern for December, no correlation with the departure of precipitation from normal can be undertaken. However, it may be remarked that over the eastern half of the country, where there is a marked deficiency of precipitation, the resultant winds are along slope or slightly down slope.

[1] Prepared by Division of Research and Education.

TABLE 1.—*Mean free-air barometric pressure in millibars, temperature in degrees Centigrade, and relative humidities in percent, obtained by airplanes and radiosondes during December 1939*

Altitude (meters) mean sea level	Stations and elevations in meters above sea level																							
	Albuquerque, N. Mex. (1620 m.)				Atlanta, Ga. (300 m.)				Barksdale Field, Shreveport, La.[1] (51 m.)				Billings, Mont. (1,089 m.)				Bismarck, N. Dak. (505 m.)				Boise, Ida. (824 m.)				Buffalo, N. Y. (220 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	31	840	3.2	55	31	982	5.3	74	21	1,011	7.6	82	31	891	2.4	53	31	955	−3.9	75	30	923	2.7	83	31	985	−0.7	83
500					31	959	7.0	70	21	957	9.7	74													31	951	−2.3	82
1,000					31	902	6.0	64	21	902	7.8	71					31	898	0.3	68	30	905	4.6	77	31	892	−4.6	84
1,500					31	848	4.3	58	21	849	5.4	69	31	847	4.2	50	31	844	−0.4	63	30	852	3.8	69	31	837	−6.0	78
2,000	31	802	4.9	49	31	798	3.2	48	21	799	3.5	64	31	796	1.5	51	31	792	−1.6	59	30	800	1.1	70	30	785	−7.4	75
2,500	31	754	2.9	47	31	750	1.7	39	21	750	1.7	61	31	748	−1.7	53	31	744	−3.8	57	30	752	−2.2	70	30	736	−9.3	73
3,000	31	708	0.6	45	31	704	−0.9	37	20	704	−0.2	56	31	702	−5.0	55	31	698	−6.8	56	30	705	−5.1	68	30	690	−11.5	72
4,000	31	625	−4.2	38	31	620	−6.3	36	17	621	−5.0	49	31	617	−11.5	56	31	613	−12.4	55	29	621	−10.4	68	28	604	−16.6	70
5,000	31	550	−10.7	34	31	546	−12.1	39	17	546	−10.9	47	30	541	−18.1	55	29	537	−19.4	56	27	544	−16.2	64	28	538	−22.4	67
6,000	31	481	−17.7	33	31	478	−18.7	39	14	479	−17.1	50	30	472	−25.1	54	28	469	−26.2	55	27	476	−22.7	62	28	460	−28.9	65
7,000	31	420	−25.3	32	31	417	−26.5	38	10	417	−23.6	46	30	411	−32.2	52	26	407	−34.2	53	27	414	−30.4	61	28	399	−36.0	64
8,000	31	366	−33.3	32	31	362	−34.7	38	7	361	−31.0	45	30	356	−38.7	52	25	352	−41.9	----	27	359	−37.2	58	28	345	−42.7	----
9,000	30	316	−40.5	31	31	313	−42.3	----	7	313	−39.4	47	30	307	−45.1	----	24	303	−48.8	----	27	310	−44.4	56	26	296	−48.1	----
10,000	30	273	−47.5	----	30	270	−49.8	----					30	264	−50.5	----	24	260	−53.2	----	27	267	−50.5	----	26	254	−51.3	----
11,000	30	234	−52.8	----	30	231	−56.0	----					28	226	−54.3	----	23	223	−54.6	----	24	229	−54.8	----	24	218	−52.6	----
12,000	30	200	−57.2	----	30	197	−59.7	----					27	193	−55.6	----	21	190	−53.9	----	23	195	−57.3	----	21	186	−51.9	----
13,000	30	170	−59.8	----	30	168	−62.0	----					27	165	−56.0	----	19	162	−54.0	----	22	166	−57.5	----	20	159	−52.9	----
14,000	29	145	−62.1	----	29	143	−64.1	----					27	141	−56.4	----	14	138	−54.7	----	22	142	−57.4	----	20	136	−54.0	----
15,000	26	123	−65.0	----	29	121	−65.9	----					26	120	−57.5	----	12	118	−54.8	----	19	121	−59.0	----	18	116	−55.0	----
16,000	25	104	−66.7	----	27	102	−67.1	----					26	103	−58.6	----	8	101	−55.2	----	16	103	−59.6	----	14	99	−56.0	----
17,000	19	88	−67.1	----	25	87	−66.4	----					21	87	−57.5	----	7	85	−54.9	----	12	87	−59.3	----	6	84	−56.4	----
18,000	9	74	−64.4	----	17	74	−65.1	----					11	74	−55.9	----	5	72	−53.3	----	5	73	−57.6	----				

Altitude (meters) mean sea level	Stations and elevations in meters above sea level																							
	Charleston, S. C. (14 m.)				Denver, Colo. (1,616 m.)				El Paso, Tex. (1,193 m.)				Ely, Nev. (1,908 m.)				Fairbanks, Alaska (153 m.)				Joliet, Ill. (178 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	30	1,016	6.4	82	30	838	−0.5	52	31	885	5.5	63	31	812	−1.9	68	30	977	−14.6	65	31	902	−0.5	83
500	30	959	9.7	60													30	934	−9.3	69	31	953	+0.6	75
1,000	30	902	7.4	51													30	876	−7.7	67	31	896	−0.4	66
1,500	30	849	5.8	47					31	853	10.0	49					30	822	−8.0	64	31	841	−1.4	58
2,000	30	798	4.3	40	30	800	5.0	49	31	802	7.6	45	31	803	0.6	64	30	770	−10.4	62	31	790	−3.1	54
2,500	30	751	2.6	36	30	752	3.2	46	31	755	5.1	42	31	754	0.8	59	30	721	−13.9	62	30	742	−5.1	51
3,000	30	705	0.4	33	30	706	−0.1	44	31	710	2.3	40	31	708	−1.7	58	30	675	−17.3	63	30	695	−7.3	51
4,000	30	622	−5.5	31	30	622	−6.7	42	31	627	−2.8	34	30	624	−6.4	49	30	590	−24.4	60	30	611	−12.3	53
5,000	29	547	−11.8	31	30	547	−13.1	42	31	552	−9.4	31	30	548	−12.7	44	30	513	−31.4	57	30	535	−18.8	51
6,000	29	480	−18.4	32	30	479	−20.2	43	31	484	−16.7	31	30	480	−19.5	42	29	444	−38.7	56	30	467	−26.1	51
7,000	29	419	−25.3	31	30	418	−27.8	43	31	422	−24.5	30	30	419	−27.1	43	29	384	−45.9	----	30	406	−33.7	50
8,000	27	363	−32.9	32	30	362	−35.6	43	31	368	−32.6	30	29	364	−34.6	42	29	329	−52.2	----	27	351	−40.8	----
9,000	25	315	−41.1	----	29	313	−43.4	----	30	318	−40.1	----	29	314	−41.8	----	28	282	−55.9	----	26	302	−46.8	----
10,000	22	271	−48.2	----	28	270	−50.4	----	30	274	−47.2	----	29	270	−48.6	----	27	241	−54.7	----	25	259	−51.9	----
11,000	20	232	−53.9	----	28	231	−54.9	----	29	235	−53.6	----	29	232	−54.1	----	26	207	−52.5	----	23	222	−53.9	----
12,000	18	198	−58.1	----	24	197	−58.0	----	29	201	−58.4	----	29	198	−57.2	----	25	177	−50.9	----	18	190	−54.1	----
13,000	16	169	−60.9	----	21	168	−59.4	----	29	171	−61.4	----	29	169	−59.1	----	21	152	−50.0	----	18	162	−54.7	----
14,000	15	143	−62.6	----	19	143	−61.3	----	29	145	−64.6	----	27	143	−60.0	----	19	131	−49.1	----	17	138	−55.9	----
15,000	13	121	−65.3	----	18	122	−62.7	----	29	123	−67.7	----	24	122	−62.0	----	17	112	−48.5	----	13	118	−56.9	----
16,000	12	103	−66.3	----	17	104	−64.2	----	29	104	−68.7	----	24	104	−63.7	----	14	96	−48.3	----	10	101	−57.1	----
17,000	10	87	−65.3	----	13	88	−63.7	----	19	88	−68.0	----	20	88	−62.4	----	10	83	−47.3	----	7	86	−57.5	----
18,000	7	74	−64.1	----	6	74	−61.1	----	6	75	−65.4	----	11	74	−61.8	----								

See footnotes at end of table.

TABLE 1.—*Mean free-air barometric pressure in millibars, temperature in degrees Centigrade, and relative humidities in percent, obtained by airplanes and radiosondes during December 1939*—Continued

Altitude (meters) mean sea level	Stations and elevations in meters above sea level																							
	Juneau, Alaska (49 m.)				Lakehurst, N. J.[1] (39 m.)				Medford, Oreg. (401 m.)				Miami, Fla. (4 m.)				Minneapolis, Minn. (263 m.)				Nashville, Tenn. (180 m.)				Norfolk, Va.[2] (10 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	29	997	4.4	82	29	1,008	−0.2	76	30	971	5.2	89	31	1,018	15.0	92	31	982	−3.2	77	31	995	4.4	74	25	1,016	4.5	76
500	29	943	1.8	83	29	952	−0.9	68	30	959	5.5	87	31	960	16.4	77	31	954	−1.8	74	31	957	4.9	71	25	957	5.8	61
1,000	29	886	−1.6	88	29	894	−2.0	66	30	903	5.9	75	31	906	13.5	75	31	896	−1.8	67	31	900	3.3	65	25	900	3.3	55
1,500	29	831	−4.5	92	29	839	−3.4	63	30	849	4.7	68	31	854	12.1	59	31	841	−1.8	56	31	846	1.7	58	25	846	1.3	52
2,000	29	780	−7.1	93	29	788	−4.8	61	30	798	2.2	63	31	804	10.7	45	31	789	−3.2	52	31	796	0.4	54	24	794	−1.1	49
2,500	26	731	−9.7	91	29	739	−6.5	62	30	750	−0.1	58	31	757	8.8	36	31	741	−5.4	52	31	748	−1.2	49	24	746	−3.5	47
3,000	22	685	−12.4	88	29	693	−9.0	63	30	704	−2.6	57	31	712	6.1	33	31	695	−8.0	51	31	702	−3.4	46	24	700	−5.7	46
4,000	18	600	−18.8	84	29	608	−14.2	62	29	620	−8.0	59	31	630	0.4	27	31	610	−13.2	50	29	618	−8.3	44	23	616	−10.8	41
5,000	15	523	−26.0	82	27	532	−20.2	63	29	545	−14.2	61	31	555	−5.5	24	31	534	−19.4	50	29	542	−13.8	43	17	541	−16.7	40
6,000	9	455	−33.7	79	27	464	−27.1	63	29	477	−21.1	63	31	488	−12.6	24	31	466	−26.8	50	27	474	−20.5	41	----	----	----	----
7,000	7	393	−40.6	----	25	403	−33.9	66	28	415	−28.2	61	31	427	−19.4	25	31	405	−34.4	50	26	414	−28.0	39	----	----	----	----
8,000	7	338	−46.6	----	23	349	−40.4	----	27	360	−36.4	58	31	373	−27.0	25	31	350	−41.9	51	24	359	−35.6	38	----	----	----	----
9,000	7	290	−51.7	----	21	300	−46.6	----	26	311	−44.0	62	31	324	−34.8	25	31	302	−48.2	----	23	311	−42.7	38	----	----	----	----
10,000	----	----	----	----	19	258	−51.3	----	23	267	−50.6	----	31	280	−42.7	----	31	259	−52.3	----	23	267	−48.9	----	----	----	----	----
11,000	----	----	----	----	16	221	−54.2	----	23	228	−56.7	----	31	241	−50.2	----	31	222	−53.6	----	22	229	−53.9	----	----	----	----	----
12,000	----	----	----	----	15	190	−55.2	----	21	195	−60.1	----	31	206	−57.2	----	31	190	−53.9	----	19	196	−57.0	----	----	----	----	----
13,000	----	----	----	----	13	162	−56.1	----	20	166	−60.0	----	31	176	−62.7	----	31	162	−54.0	----	18	166	−59.9	----	----	----	----	----
14,000	----	----	----	----	12	138	−57.3	----	17	141	−60.6	----	30	149	−66.9	----	30	139	−54.5	----	18	141	−61.7	----	----	----	----	----
15,000	----	----	----	----	9	118	−58.6	----	14	120	−61.9	----	30	126	−69.9	----	26	119	−55.4	----	17	120	−62.8	----	----	----	----	----
16,000	----	----	----	----	7	100	−59.6	----	11	102	−63.7	----	28	106	−71.1	----	21	102	−55.7	----	14	101	−63.3	----	----	----	----	----
17,000	----	----	----	----	----	----	----	----	8	86	−62.5	----	25	90	−71.1	----	11	87	−55.4	----	11	86	−63.7	----	----	----	----	----
18,000	----	----	----	----	----	----	----	----	7	72	−60.4	----	20	76	−70.1	----	6	74	−55.7	----	6	72	−62.7	----	----	----	----	----
19,000	----	----	----	----	----	----	----	----	----	----	----	----	11	64	−68.3	----	----	----	----	----	----	----	----	----	----	----	----	----
20,000	----	----	----	----	----	----	----	----	----	----	----	----	5	54	−65.6	----	----	----	----	----	----	----	----	----	----	----	----	----

Altitude (meters) mean sea level	Stations and elevations in meters above sea level																							
	Oakland, Calif. (2 m.)				Oklahoma City, Okla. (391 m.)				Omaha, Nebr. (301 m.)				Pearl Harbor, T. H.[1] (6 m.)				Pensacola, Fla.[1] (24 m.)				Phoenix, Ariz. (339 m.)				St. Louis, Mo. (171 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	31	1,020	9.0	84	31	972	4.6	63	31	981	−0.9	75	31	1,015	29.4	85	30	1,018	12.2	73	31	977	9.3	68	31	996	1.7	77
500	31	961	10.5	72	31	959	7.2	58	31	957	1.9	69	31	959	19.5	76	30	961	11.5	61	31	959	13.7	63	31	956	2.9	71
1,000	31	905	8.9	65	31	902	8.0	47	31	899	2.6	58	31	905	15.6	83	30	905	9.1	58	31	904	14.8	52	31	898	2.1	66
1,500	31	852	7.7	57	31	849	6.2	43	31	845	1.4	54	31	854	12.6	81	30	852	8.0	48	31	852	12.1	47	31	844	0.8	60
2,000	31	801	5.8	50	31	798	4.3	38	31	794	−0.5	53	31	804	13.2	51	30	802	6.6	38	31	802	9.4	45	31	794	−0.9	55
2,500	31	754	3.4	44	31	751	2.2	36	31	746	−2.6	53	31	757	12.5	33	30	754	4.7	32	31	755	6.6	42	31	745	−2.9	51
3,000	31	708	0.8	40	31	705	−0.4	35	31	700	−4.8	50	31	713	10.5	21	30	709	2.8	30	31	710	3.9	40	31	699	−5.5	50
4,000	31	625	−5.0	39	31	622	−6.2	33	30	616	−10.6	49	31	632	4.7	15	30	626	−2.5	30	30	627	−2.5	38	31	614	−11.2	45
5,000	31	550	−11.4	42	30	546	−12.7	31	30	540	−17.0	49	----	----	----	----	29	551	−8.6	32	30	552	−9.1	36	31	539	−17.2	43
6,000	31	481	−18.4	40	29	479	−19.4	27	30	472	−24.3	48	----	----	----	----	29	484	−15.5	35	30	484	−16.7	34	30	471	−24.3	44
7,000	31	420	−26.0	39	29	418	−27.1	27	30	410	−32.2	47	----	----	----	----	29	423	−22.1	37	30	423	−24.5	33	30	409	−31.9	44
8,000	29	365	−34.1	39	27	363	−34.7	27	30	355	−40.0	47	----	----	----	----	29	368	−29.3	44	30	368	−32.7	32	29	355	−38.9	44
9,000	29	316	−42.0	39	27	314	−41.4	----	30	306	−46.7	----	----	----	----	----	29	319	−36.7	45	30	318	−40.6	32	28	306	−45.6	----
10,000	29	272	−49.5	----	25	270	−48.0	----	29	263	−51.9	----	----	----	----	----	29	276	−44.0	----	29	274	−48.3	----	27	263	−51.3	----
11,000	29	233	−55.8	----	23	231	−54.3	----	29	225	−54.7	----	----	----	----	----	29	238	−51.0	----	28	235	−54.3	----	25	225	−55.4	----
12,000	29	199	−59.8	----	22	197	−58.1	----	28	192	−55.8	----	----	----	----	----	29	205	−56.6	----	28	201	−58.1	----	22	192	−57.0	----
13,000	29	169	−61.0	----	22	168	−59.1	----	28	164	−56.6	----	----	----	----	----	26	173	−60.2	----	27	171	−61.0	----	20	165	−57.7	----
14,000	29	144	−62.6	----	21	143	−61.3	----	28	140	−57.5	----	----	----	----	----	25	147	−62.9	----	27	145	−64.0	----	19	140	−59.0	----
15,000	29	122	−65.1	----	18	121	−63.8	----	25	120	−59.0	----	----	----	----	----	23	125	−65.0	----	25	123	−66.9	----	19	120	−60.7	----
16,000	24	104	−66.6	----	14	103	−64.9	----	23	102	−60.1	----	----	----	----	----	20	106	−66.9	----	24	104	−69.8	----	15	102	−61.8	----
17,000	21	88	−66.7	----	10	86	−64.9	----	10	87	−59.4	----	----	----	----	----	14	90	−67.8	----	23	88	−69.6	----	10	87	−61.6	----
18,000	16	74	−65.0	----	5	73	−63.6	----	----	----	----	----	----	----	----	----	11	76	−68.4	----	18	74	−67.6	----	----	----	----	----
19,000	8	63	−63.2	----	----	----	----	----	----	----	----	----	----	----	----	----	7	64	−68.0	----	11	63	−65.0	----	----	----	----	----
20,000	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	5	54	−67.3	----	----	----	----	----	----	----	----	----

See footnotes at end of table.

TABLE 1.—*Mean free-air barometric pressure in millibars, temperature in degrees Centigrade, and relative humidities in percent, obtained by airplanes and radiosondes during December 1939*—Continued

Altitude (meters) mean sea level	Stations and elevations in meters above sea level																	
	San Antonio, Tex. (174 m.)				San Diego, Calif.[1] (10 m.)				S. Ste. Marie, Mich. (221 m.)				Spokane, Wash. (598 m.)				Washington, D. C.[2] (7 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	31	999	10.7	75	29	1,016	12.3	80	31	983	−3.4	84	31	948	1.8	80	27	1,013	2.5	76
500	31	961	14.3	66	29	958	16.1	57	31	949	−4.7	88					27	953	1.6	66
1,000	31	906	12.5	58	29	904	15.0	48	31	890	−6.2	87	31	902	1.9	83	27	897	0.2	67
1,500	31	853	10.6	55	29	852	12.9	41	31	835	−6.5	80	30	847	0.1	78	27	842	−1.5	62
2,000	31	803	8.9	48	29	802	10.6	35	31	784	−7.8	75	30	795	−2.5	73	27	790	−3.3	61
2,500	31	756	6.6	42	29	755	8.0	31	31	734	−9.8	74	30	747	−5.2	70	27	741	−5.4	60
3,000	31	711	4.0	40	29	710	5.0	28	31	688	−12.2	72	29	700	−8.0	69	27	696	−7.6	58
4,000	31	628	−1.6	39	27	627	−2.0	26	31	603	−17.9	70	29	615	−12.9	62	27	611	−12.4	59
5,000	31	553	−7.7	39	9	553	−9.2	32	31	527	−24.0	68	28	539	−19.2	62	27	535	−18.2	57
6,000	29	486	−14.8	39					31	459	−31.1	65	28	470	−25.6	64	26	468	−25.3	56
7,000	29	425	−22.8	39					31	397	−37.9	65	28	409	−32.6	64	26	407	−32.6	56
8,000	29	370	−30.0	38					30	343	−44.7		28	354	−39.7	62	23	352	−39.2	55
9,000	29	320	−37.4	39					30	295	−50.0		28	305	−46.1		23	304	−45.0	
10,000	29	276	−44.7						30	252	−53.1		27	262	−51.8		20	261	−49.5	
11,000	29	237	−51.0						30	216	−52.9		27	225	−54.8		17	224	−54.3	
12,000	29	203	−56.0						25	185	−52.5		24	192	−55.5		12	191	−57.2	
13,000	29	174	−59.5						22	158	−52.8		23	164	−54.8		8	163	−58.5	
14,000	28	148	−62.1						16	135	−53.8		21	140	−55.4					
15,000	26	125	−64.8						10	116	−53.7		21	120	−56.4					
16,000	23	106	−66.9						5	98	−52.5		20	102	−56.6					
17,000	23	90	−67.5										11	88	−56.8					
18,000	17	76	−66.1										5	75	−55.6					
19,000	12	64	−64.8										5	64	−53.5					
20,000	6	54	−63.4																	

[1] Army. Taken at approximately 2 a. m., 75th meridian time.
[2] Navy. Taken at 4 a. m., 75th meridian time, except San Diego, Calif., and Pearl Harbor, T. H., where they are made at dawn.

Observations taken at 1 a. m., 75th meridian time.
Number of observation refers to pressure only as temperature and humidity data are missing for some observations at certain levels; also, the humidity data are not used in daily observations when the temperature is below −40.0 ° C.
None of the means included in this table are based on less than 15 surface and 5 standard-level observations.

LATE REPORT FOR FAIRBANKS, ALASKA, SEPTEMBER 1939

Altitude (meters) m. s. l.	Stations and elevations in meters above sea level				Altitude (meters) m. s. l.	Stations and elevations in meters above sea level				Altitude (meters) m. s. l.	Stations and elevations in meters above sea level			
	Fairbanks, Alaska (152 m.)					Fairbanks, Alaska (152 m.)					Fairbanks, Alaska (152 m.)			
	Number of observations	Pressure	Temperature	Relative humidity		Number of observations	Pressure	Temperature	Relative humidity		Number of observations	Pressure	Temperature	Relative humidity
Surface	19	994	4.6	74	3,000	19	694	−9.8	78	10,000	12	257	−52.7	
500	19	952	4.7	74	4,000	17	609	−15.7	76	11,000	11	220	−52.9	
1,000	19	895	1.7	78	5,000	17	532	−22.2	73	12,000	9	188	−52.6	
1,500	19	841	−1.5	81	6,000	16	464	−29.3	70	13,000	8	161	−53.0	
2,000	19	790	−4.4	81	7,000	15	402	−36.7	68	14,000	8	138	−53.3	
2,500	19	740	−7.1	80	8,000	14	348	−43.7		15,000	7	117	−53.8	
					9,000	12	299	−49.1		16,000	6	100	−53.8	

208641—40——3

TABLE 1.—*Mean free-air barometric pressure in millibars, temperature in degrees Centigrade, and relative humidities in percent, obtained by airplanes and radiosondes during December 1939*—Continued

LATE REPORT FOR SAN ANTONIO, TEX., FOR AUGUST, SEPTEMBER AND OCTOBER 1939

Altitude (meters) mean sea level	Stations and elevations in meters above sea level											
	August (174 m.)				September (174 m.)				October (174 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	31	994	24.2	85	29	995	22.7	84	31	998	18.8	71
500	31	958	23.5	82	29	959	22.4	78	31	960	19.9	68
1,000	31	905	22.5	70	29	905	20.5	69	31	906	17.9	61
1,500	31	855	19.7	67	29	854	18.2	65	31	855	15.5	60
2,000	31	806	16.8	68	29	805	15.2	64	31	805	13.5	53
2,500	31	760	13.9	67	29	759	12.7	62	31	759	11.0	51
3,000	31	716	11.0	65	29	715	9.9	60	31	714	8.6	51
4,000	30	635	5.3	64	28	633	4.7	53	31	632	3.4	50
5,000	30	561	−0.3	63	28	560	−0.7	50	31	558	−2.1	47
6,000	30	495	−5.8	59	27	494	−6.6	41	31	492	−8.4	43
7,000	29	435	−12.4	56	27	434	−13.1	36	31	431	−15.2	40
8,000	29	380	−19.1	51	27	379	−20.5	35	31	378	−22.1	38
9,000	29	332	−26.5	48	26	330	−27.8	34	31	328	−29.6	37
10,000	29	289	−34.0	48	26	286	−35.5	33	31	285	−36.9	36
11,000	29	249	−41.8	----------	26	246	−43.2	----------	30	246	−44.2	----------
12,000	26	215	−49.3	----------	26	212	−50.6	----------	30	211	−50.7	----------
13,000	25	184	−56.3	----------	26	182	−57.5	----------	29	181	−56.3	----------
14,000	25	157	−62.3	----------	26	154	−63.3	----------	29	154	−61.9	----------
15,000	24	133	−66.7	----------	26	131	−67.9	----------	28	131	−66.8	----------
16,000	24	113	−69.4	----------	26	111	−70.6	----------	28	111	−70.1	----------
17,000	23	95	−68.8	----------	26	93	−71.5	----------	26	94	−70.3	----------
18,000	21	81	−66.7	----------	24	79	−70.2	----------	21	79	−68.9	----------
19,000	16	68	−64.0	----------	21	66	−67.1	----------	16	67	−66.1	----------
20,000	13	58	−61.6	----------	14	56	−63.5	----------	14	56	−62.5	----------
21,000	11	49	−60.1	----------	6	47	−60.5	----------	10	47	−60.2	----------
22,000	7	42	−58.4	----------	----------	----------	----------	----------	5	40	−57.8	----------

LATE REPORT SWAN ISLAND, WEST INDIES, AUGUST 1939

Altitude (meters) mean sea level	Swan Island, West Indies (10 m.)				Altitude (meters) mean sea level	Swan Island, West Indies (10 m.)				Altitude (meters) mean sea level	Swan Island, West Indies (10 m.)			
	Number of observations	Pressure	Temperature	Relative humidity		Number of observations	Pressure	Temperature	Relative humidity		Number of observations	Pressure	Temperature	Relative humidity
Surface	31	1,010	26.7	85	6,000	31	490	−9.2	48	15,000	31	129	−71.8	----------
500	31	957	22.5	88	7,000	31	430	−15.2	47	16,000	31	109	−73.9	----------
1,000	31	904	19.4	82	8,000	31	376	−21.7	46	17,000	30	92	−73.8	----------
1,500	31	853	16.5	75	9,000	31	328	−28.9	45	18,000	26	78	−72.5	----------
2,000	31	804	13.8	68	10,000	31	284	−36.6	45	19,000	25	68	−70.5	----------
2,500	31	757	10.9	63	11,000	31	246	−44.6	----------	20,000	22	55	−68.2	----------
3,000	31	713	8.2	56	12,000	31	211	−52.6	----------	21,000	9	46	−66.5	----------
4,000	31	631	2.7	52	13,000	31	180	−60.5	----------	22,000	7	39	−65.0	----------
5,000	31	557	−3.3	51	14,000	31	153	−67.4	----------					

TABLE 2.—*Free-air resultant winds based on pilot-balloon observations made near 5 p. m. (E. S. T.) during December 1939*

[Directions given in degrees from north (N=360°, E=90°, S=180°, W=270°)—Velocities in meters per second (superior figures indicate number of observations)]

Altitude (meters) m. s. l.	Abilene, Tex. (537 m.)		Albuquerque, N. Mex. (1,554 m.)		Atlanta, Ga. (302 m.)		Billings, Mont. (1,095 m.)		Boise, Idaho (850 m.)		New York, N. Y. (15 m.)		Brownsville, Tex. (7 m.)		Buffalo, N. Y. (220 m.)		Burlington, Vt. (132 m.)		Charleston, S. C. (18 m.)		Cheyenne, Wyo. (1,873 m.)		Chicago, Ill. (192 m.)		Cincinnati, Ohio (157 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	271^{20}	2.5	309^{21}	0.8	272^{29}	3.9	259^{31}	4.2	193^{27}	0.7	297^{29}	5.6	122^{29}	2.8	253^{29}	4.0	264^{29}	1.4	254^{31}	1.9	281^{29}	6.5	270^{29}	2.9	259^{31}	2.8
500	----------	----------	----------	----------	277^{29}	4.6	----------	----------	294^{29}	8.6	149^{29}	3.2	251^{29}	6.5	263^{29}	4.1	256^{31}	4.7	----------	----------	276^{29}	5.2	252^{31}	5.7
1,000	276^{29}	3.0	----------	----------	277^{27}	6.0	150^{27}	1.6	287^{29}	9.7	215^{29}	2.0	261^{24}	10.3	276^{24}	5.9	250^{29}	7.9	----------	----------	290^{29}	7.9	259^{24}	7.6
1,500	292^{29}	4.5	----------	----------	288^{27}	8.2	267^{31}	8.2	154^{27}	2.8	293^{29}	11.0	276^{24}	3.4	277^{14}	9.9	283^{13}	6.7	260^{27}	11.0	----------	----------	296^{29}	10.1	282^{31}	9.7
2,000	290^{29}	6.1	306^{31}	1.9	294^{31}	10.9	276^{29}	10.2	211^{29}	2.8	297^{29}	12.7	283^{29}	4.4	293^{10}	9.2	----------	----------	267^{24}	13.3	281^{29}	7.4	297^{29}	12.3	286^{29}	13.0
2,500	290^{29}	6.6	313^{31}	4.8	291^{31}	12.6	278^{29}	10.9	239^{29}	6.1	295^{13}	9.4	282^{29}	5.7	----------	----------	----------	----------	268^{29}	16.1	291^{29}	9.8	301^{14}	12.8	300^{13}	13.9
3,000	283^{29}	7.8	307^{31}	8.1	291^{31}	14.3	284^{29}	11.1	245^{29}	7.8	289^{10}	9.4	277^{29}	5.7	----------	----------	----------	----------	270^{10}	14.2	298^{29}	10.4	309^{14}	14.9	319^{13}	16.1
4,000	289^{31}	9.6	307^{29}	10.7	289^{29}	17.7	296^{31}	17.4	263^{13}	9.2	----------	----------	283^{13}	7.6	----------	----------	----------	----------	271^{10}	15.7	302^{27}	13.2	----------	----------	----------	----------
5,000	292^{29}	12.2	309^{27}	13.7	290^{13}	19.8	298^{29}	19.0	----------	----------	----------	----------	296^{13}	9.5	----------	----------	----------	----------	----------	----------	297^{29}	14.9	----------	----------	----------	----------
6,000	296^{24}	11.9	305^{27}	14.9	291^{10}	20.6	308^{17}	21.2	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	296^{24}	17.1	----------	----------	----------	----------
8,000	299^{29}	12.4	277^{29}	13.7	302^{10}	19.3	312^{10}	23.8	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	315^{13}	21.7	----------	----------	----------	----------
10,000	282^{17}	13.0	296^{13}	16.3	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
12,000	291^{14}	12.6	309^{11}	18.9	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
14,000	287^{11}	14.9	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
16,000	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------
18,000	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------

TABLE 2.—*Free-air resultant winds based on pilot-balloon observations made near 5 p. m. (E. S. T.) during December 1939*—Continued

Altitude (meters) m. s. l.	El Paso, Tex. (1,196 m.)		Fargo, N. Dak. (283 m.)		Greensboro, N. C. (271 m.)		Havre, Mont. (766 m.)		Houston, Tex. (21 m.)		Huron, S. Dak. (393 m.)		Las Vegas, Nev. (570 m.)		Little Rock, Ark. (79 m.)		Medford, Oreg. (410 m.)		Miami, Fla. (10 m.)		Minneapolis, Minn. (261 m.)		Nashville, Tenn. (194 m.)		New Orleans, La. (19 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	317[31]	0.6	294[37]	2.3	252[28]	2.5	256[30]	3.9	246[36]	1.4	306[31]	3.7	87[31]	0.7	223[28]	1.3	349[23]	1.4	334[31]	0.4	283[30]	2.4	283[19]	2.4	345[37]	2.1
500			293[37]	4.2	251[28]	4.6			239[30]	2.5	306[31]	4.4			236[28]	3.8	16[22]	1.0	308[31]	0.4	272[23]	3.4	257[26]	3.9	266[37]	2.3
1,000			290[19]	8.5	260[26]	7.5	252[26]	8.4	232[30]	4.0	305[28]	6.6	51[21]	2.1	249[28]	6.3	155[30]	3.3	273[31]	1.7	292[26]	6.5	266[27]	5.5	268[26]	4.0
1,500	280[21]	1.1	297[19]	10.2	281[26]	9.3	267[26]	11.9	238[27]	5.7	312[26]	10.0	30[21]	1.2	276[24]	8.1	204[19]	5.3	266[31]	4.0	303[24]	8.1	280[25]	8.0	283[25]	6.0
2,000	271[21]	2.4	303[18]	11.5	292[23]	13.0	273[26]	12.1	286[24]	7.1	313[24]	10.9	270[21]	1.0	290[22]	10.2	220[13]	7.8	277[26]	6.3	313[22]	10.6	289[22]	10.4	288[24]	7.7
2,500	290[21]	4.3	297[18]	13.1	286[26]	15.7	280[26]	13.1	282[23]	7.9	315[23]	13.0	264[21]	2.6	298[22]	11.4	228[13]	10.6	274[26]	7.0	314[23]	11.8	291[21]	11.9	285[23]	8.4
3,000	292[21]	5.3	297[17]	13.8	289[19]	17.6	283[23]	12.1	289[23]	8.5	312[23]	15.3	267[21]	4.0	294[22]	13.1	------	------	274[26]	7.2	311[19]	12.9	300[19]	14.7	287[23]	9.9
4,000	295[20]	7.1	300[16]	16.3	286[19]	22.5	295[13]	10.2	289[23]	11.1	305[27]	18.7	279[20]	6.8	297[18]	13.7	------	------	264[26]	9.3	298[11]	15.5	296[16]	18.5	292[27]	11.4
5,000	292[20]	6.6	------	------	293[19]	25.2	289[16]	15.4	282[21]	12.2	307[23]	22.3	282[20]	8.6	304[18]	16.5	------	------	266[16]	11.9	------	------	296[19]	21.8	------	------
6,000	293[20]	8.3	------	------	290[19]	30.8	------	------	281[21]	13.7	306[19]	23.2	287[20]	11.0	295[18]	16.5	------	------	265[16]	15.4	------	------	------	------	------	------
8,000	305[13]	6.3	------	------	290[13]	35.8	------	------	295[13]	15.2	311[16]	27.0	265[20]	12.8	------	------	------	------	264[16]	21.7	------	------	------	------	------	------
10,000	------	------	------	------	------	------	------	------	------	------	317[11]	28.8	301[20]	16.3	------	------	------	------	262[21]	26.3	------	------	------	------	------	------
12,000	------	------	------	------	------	------	------	------	------	------	------	------	297[21]	18.6	------	------	------	------	------	------	------	------	------	------	------	------
14,000	------	------	------	------	------	------	------	------	------	------	------	------	307[16]	14.2	------	------	------	------	------	------	------	------	------	------	------	------
16,000	------	------	------	------	------	------	------	------	------	------	------	------	311[13]	12.8	------	------	------	------	------	------	------	------	------	------	------	------
18,000	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------

Altitude (meters) m. s. l.	Oakland, Calif. (8 m.)		Oklahoma City, Okla. (402 m.)		Omaha, Nebr. (306 m.)		Reno, Nev. (1,346 m.)		St. Louis, Mo. (170 m.)		Salt Lake City, Utah (1,294 m.)		San Diego, Calif. (15 m.)		San Juan, P. R. (16 m.)		Sault Ste. Marie, Mich. (198 m.)		Seattle, Wash. (14 m.)		Spokane, Wash. (603 m.)		Washington, D. C. (10 m.)		Winslow, Ariz. (1,488 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	218[30]	1.6	320[23]	2.2	296[28]	2.2	151[21]	1.1	276[32]	2.1	237[29]	1.2	283[31]	3.6	84[31]	5.2	316[28]	2.4	182[23]	2.0	205[32]	1.4	276[30]	2.7	331[21]	0.5
500	219[30]	0.3	319[23]	2.2	287[28]	3.3	------	------	262[29]	4.3	------	------	305[31]	2.8	97[31]	6.4	307[28]	3.2	188[23]	4.8	------	------	277[30]	5.9	------	------
1,000	259[28]	2.0	305[24]	2.2	298[27]	5.8	------	------	266[27]	6.0	------	------	324[31]	1.0	109[30]	5.0	318[30]	6.3	299[24]	7.8	195[32]	3.4	280[29]	9.4	------	------
1,500	251[28]	2.9	303[23]	5.5	305[32]	7.9	163[21]	1.1	297[22]	6.8	215[29]	1.5	359[25]	0.8	118[30]	4.0	333[12]	10.4	208[29]	8.1	210[32]	7.6	282[27]	11.1	------	------
2,000	276[23]	3.5	301[23]	7.5	300[28]	8.6	190[21]	2.8	298[21]	9.1	213[29]	2.8	337[29]	1.1	115[24]	3.4	333[12]	13.3	220[16]	7.4	230[28]	8.7	288[23]	13.5	337[24]	0.8
2,500	266[21]	4.3	304[23]	8.3	299[23]	11.3	220[21]	4.3	292[20]	11.4	234[29]	2.7	318[29]	2.0	108[23]	3.4	331[11]	15.7	231[15]	7.9	233[16]	9.7	292[21]	14.9	294[21]	2.9
3,000	286[19]	4.7	301[24]	9.8	303[21]	13.1	258[20]	6.8	297[16]	13.6	250[27]	4.5	316[29]	3.0	101[18]	3.2	------	------	235[11]	8.3	232[17]	10.5	288[16]	15.8	290[21]	3.9
4,000	299[16]	7.8	311[23]	12.4	310[19]	17.4	264[24]	11.0	311[13]	14.5	287[26]	8.7	302[23]	4.2	98[16]	2.0	------	------	------	------	249[13]	10.5	295[13]	18.2	304[20]	6.6
5,000	288[11]	7.7	307[23]	13.3	310[18]	20.3	281[21]	12.5	------	------	298[20]	12.7	302[20]	4.2	120[13]	1.5	------	------	------	------	272[16]	14.0	------	------	301[27]	7.6
6,000	------	------	304[21]	14.3	310[16]	21.7	278[17]	12.2	------	------	301[13]	12.6	265[20]	3.8	308[13]	0.6	------	------	------	------	------	------	------	------	298[27]	9.6
8,000	------	------	298[17]	16.2	313[13]	24.7	288[11]	19.0	------	------	------	------	------	------	258[16]	6.7	------	------	------	------	------	------	------	------	283[23]	11.2
10,000	------	------	293[12]	15.7	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	283[21]	12.2
12,000	------	------	290[16]	21.7	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	300[19]	14.0
14,000	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	305[18]	15.4
16,000	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	289[13]	10.9

TABLE 3.—*Maximum free-air velocity, (M. P. S.), for different sections of the United States based on pilot balloon observations during December 1939*

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station
Northeast [1]	51.6	WNW	2,360	31	Harrisburg, Pa.	54.6	WNW	3,880	9	Hartford, Conn.	45.0	NNW	5,650	24	Kylertown, Pa.
East-Central [2]	56.6	W	2,480	31	Richmond, Va.	52.9	WNW	5,000	31	Knoxville, Tenn.	76.0	WNW	9,400	5	Greensboro, N. C.
Southeast [3]	37.4	WNW	2,500	21	Spartanburg, S. C.	43.5	W	4,980	20	Atlanta, Ga.	88.5	WSW	13,900	31	Miami, Fla.
North-Central [4]	40.0	WNW	1,990	16	Fargo, N. Dak.	54.4	NW	4,260	7	Milwaukee, Wis.	75.0	NW	10,060	13	Huron, S. Dak.
Central [5]	35.6	NNW	1,280	2	Kansas City, Mo.	46.0	W	3,040	9	Indianapolis, Ind.	87.5	WSW	11,960	22	Omaha, Nebr.
South-Central [6]	32.1	WNW	2,070	23	Abilene, Tex.	42.0	NNW	4,270	2	Oklahoma City, Okla.	62.0	W	11,770	21	Oklahoma City, Okla.
Northwest [7]	39.0	W	1,570	2	Havre, Mont.	46.4	WNW	3,380	11	Havre, Mont.	50.0	NNW	9,440	1	Billings, Mont.
West-Central [8]	39.6	SSW	2,440	10	Sacramento, Calif.	61.8	WSW	4,210	16	Redding, Calif.	73.6	NNW	10,200	26	Reno, Nev.
Southwest [9]	30.9	WNW	2,190	23	El Paso, Tex.	47.0	NNW	4,880	29	Albuquerque, N. Mex.	69.4	NNW	9,980	22	Las Vegas, Nev.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

TABLE 4.—*Mean altitude and temperatures of significant points identifiable as tropopauses during December 1939, classified according to the potential temperatures (10-degree intervals between 290° and 409° A.) with which they are identified. (Based on radiosonde observations)*

Potential temperatures, °A	Albuquerque, N. Mex.			Atlanta, Ga.			Billings, Mont.			Bismarck, N. Dak.			Boise, Idaho			Buffalo, N. Y.			Charleston, S. C.		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290–299							7	6.5	−41.3	3	6.0	−34.7	4	6.9	−43.2	2	6.3	−42.0			
300–309	1	8.0	−46.0				8	7.8	−47.2	14	7.9	−48.0	3	7.9	−46.7	18	7.4	−43.6	2	9.3	−53.5
310–319	7	8.7	−47.6	9	9.1	−48.2	13	9.0	−48.1	23	9.4	−54.6	11	9.0	−48.9	22	9.0	−51.1	7	8.8	−45.0
320–329	19	10.3	−52.1	21	10.3	−53.7	23	10.5	−56.3	11	10.3	−56.2	17	10.5	−56.1	17	10.3	−56.7	10	10.2	−51.4
330–339	17	11.6	−58.4	18	11.6	−59.1	9	11.5	−59.2	6	11.3	−57.2	16	11.7	−60.5	6	11.1	−56.5	14	11.7	−59.9
340–349	9	12.7	−62.9	9	12.7	−64.3	2	12.4	−63.5	2	12.0	−58.0	5	12.8	−64.8	3	11.8	−56.7	6	12.7	−63.2
350–359				3	14.2	−70.3				1	12.9	−60.0							4	13.2	−63.5
360–369	6	14.7	−69.5	7	14.1	−67.0	2	13.4	−59.5	1	14.1	−69.0							2	14.5	−68.5
370–379	4	15.0	−67.5	4	15.1	−68.5	1	15.2	−68.0				1	15.0	−68.0	1	14.0	−61.0	3	14.9	−66.7
380–389	4	15.8	−70.8	8	15.5	−68.4	1	15.1	−66.0	2	15.0	−62.5									
390–399	10	16.5	−70.7	7	16.0	−67.6	4	15.6	−62.5				3	15.5	−64.3	2	14.8	−58.5	4	16.0	−68.5
400–409	3	16.5	−68.0	4	16.3	−66.2	2	15.8	−60.5				1	16.3	−63.0	2	15.5	−60.0	2	16.6	−67.0
Weighted means		12.5	−60.1		12.5	−60.5		10.4	−53.8		9.6	−53.4		10.8	−56.1		9.5	−51.5		12.3	−58.4
Mean potential temperature °A. (weighted)		348.1			348.3			322.5			318.8			329.5			322.3			342.6	

Potential temperatures, °A.	Denver, Colo.			El Paso, Tex.			Ely, Nev.			Fairbanks, Alaska			Joliet, Ill.			Lakehurst, N. J.			Medford, Oreg.		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290–299										26	6.8	−47.1				1	5.9	−34.0			
300–309	1	7.0	−39.0	1	8.6	−50.0	9	7.2	−40.0	33	8.3	−55.5	9	7.1	−40.9	6	7.1	−41.0	4	7.5	−43.2
310–319	16	9.0	−48.5	8	8.2	−39.2	12	8.3	−40.8	15	9.1	−54.9	16	9.0	−49.1	13	9.0	−50.5	8	8.7	−46.0
320–329	27	10.3	−53.6	14	10.1	−50.4	27	10.4	−54.0	6	9.6	−53.8	15	10.3	−55.2	5	10.2	−54.4	15	10.6	−56.4
330–339	14	11.6	−59.1	19	11.5	−57.5	17	11.6	−59.1	3	10.6	−56.0	6	10.8	−55.8	4	11.0	−57.0	10	11.7	−60.6
340–349	4	12.6	−62.2	12	12.6	−61.3	7	12.6	−62.1				3	11.9	−57.3	1	11.1	−54.0	5	12.6	−61.5
350–359	1	14.1	−68.0	5	14.3	−70.0	3	13.3	−64.0				1	13.5	−64.0	1	13.3	−62.0	1	12.4	−57.0
360–369	3	14.2	−65.0	10	14.7	−70.1	5	14.2	−65.4				1	13.3	−62.0				3	14.3	−66.0
370–379	1	15.2	−71.0	10	15.4	−70.8	7	14.8	−66.1				1	15.0	−66.0				2	14.0	−59.0
380–389	2	15.4	−67.0	9	15.7	−69.3	3	15.9	−68.7												
390–399	4	15.6	−64.5	6	16.4	−70.5	4	16.4	−67.0							1	15.3	−61.0	5	16.1	−67.4
400–409	2	16.0	−63.0	1	16.7	−71.0	1	17.0	−70.0										1	16.2	−63.0
Weighted means		11.2	−55.9		12.9	−61.5		11.3	−55.5		8.1	−52.7		9.7	−51.6		9.7	−52.0		11.5	−56.9
Mean potential temperature °A. (weighted)		335.2			353.2			337.3			305.6			322.9			321.3			338.1	

Potential temperatures, °A.	Miami, Fla.			Minneapolis, Minn.			Nashville, Tenn.			Oakland, Calif.			Oklahoma, Okla.			Omaha, Nebr.			Pensacola, Fla.		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290–299																2	6.4	−39.5			
300–309				17	7.6	−44.8	2	6.8	−33.0				1	7.2	−38.0	8	7.7	−46.0			
310–319				21	8.0	−49.7	9	8.8	−45.3	10	9.4	−51.7	7	8.6	−46.7	22	8.9	−49.1			
320–329	9	10.0	−47.6	21	10.1	−53.5	15	9.9	−49.4	21	10.4	−53.7	12	10.7	−56.8	18	10.0	−51.8	4	9.1	−42.0
330–339	18	10.9	−56.8	7	11.2	−59.0	13	11.0	−54.8	22	11.8	−60.8	16	11.5	−57.6	14	11.3	−57.9	15	11.0	−52.9
340–349	20	12.8	−61.9	3	12.1	−60.0	5	12.4	−60.2	7	12.4	−60.9	6	12.2	−58.8	5	12.4	−61.8	10	12.4	−60.0
350–359	16	13.9	−67.4	2	12.6	−58.0	3	13.2	−63.7	4	13.3	−64.0	2	13.1	−58.0	1	13.2	−62.0	6	13.1	−60.8
360–369	10	14.7	−69.5	2	13.4	−60.0	3	14.3	−66.0	5	14.4	−68.0	5	14.5	−68.2	1	13.6	−61.0			
370–379	8	15.6	−71.5				4	14.8	−66.5	5	14.8	−66.6	2	14.8	−64.5	1	14.2	−62.0	1	14.4	−63.0
380–389	8	15.9	−70.6	1	14.5	−57.0	4	14.8	−59.8	7	15.6	−70.1	4	15.5	−66.5	2	15.0	−64.0	2	16.2	−73.0
390–399	5	16.6	−71.8	4	14.8	−56.8				5	16.0	−68.4	3	16.1	−69.0	2	16.3	−67.9	1	16.7	−69.0
400–409	3	17.4	−73.7	1	15.7	−60.0	2	16.4	−67.0	7	16.5	−66.3	2	16.5	−65.0	3	15.7	−60.7			
Weighted means		13.1	−62.4		9.9	−51.9		11.2	−54.3		12.3	−59.9		12.1	−58.5		10.4	−53.3		12.0	−56.5
Mean potential temperature ° A. (weighted)		347.3			326.6			339.9			347.4			344.0			329.5			343.4	

TABLE 4.—*Mean altitudes and temperatures of significant points identifiable as tropopauses during December 1939, classified according to the potential temperatures (10-degree intervals between 290° and 409° A.) with which they are identified. (Based on radiosonde observations)*—Continued

Potential temperatures, °A.	Phoenix, Ariz.			St. Louis, Mo.			San Antonio, Tex.			Sault Ste. Marie, Mich.			Spokane, Wash.		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
290–299				2	6.6	−41.5				8	6.3	−40.5	4	5.8	−36.0
300–309	1	7.7	−44.0	6	7.9	−49.2				20	7.9	−48.6	9	7.2	−41.4
310–319	7	9.1	−48.0	13	9.1	−50.2	2	8.0	−38.5	22	9.2	−53.4	18	9.0	−49.4
320–329	19	10.2	−51.5	17	10.3	−54.1	10	10.0	−49.9	15	10.2	−56.1	26	10.4	−55.1
330–339	18	11.2	−55.3	10	11.7	−60.5	20	11.1	−53.4	6	11.2	−59.5	9	11.1	−56.8
340–349	10	12.5	−60.1	6	11.7	−56.5	14	12.5	−59.9	2	11.0	−53.5	1	12.3	−63.0
350–359	3	13.5	−65.3	1	13.1	−61.0	5	13.1	−61.4						
360–369	9	14.6	−68.4	2	13.6	−55.5	5	14.0	−63.6				1	13.5	−63.0
370–379	2	15.4	−70.5	3	14.7	−66.3	7	15.3	−68.6				3	14.2	−63.3
380–389	10	16.1	−72.6	2	14.4	−60.0	10	15.7	−68.3	1	14.0	−59.0			
390–399	5	16.3	−70.8				4	16.8	−72.8						
400–409	3	16.9	−71.3	6	15.9	−62.7	7	16.9	−70.6				1	15.2	−54.0
Weighted means		12.5	−59.8		11.0	−55.3		13.0	−60.2		9.0	−51.8		9.8	−51.7
Mean potential temperature °A. (weighted)	347.5			330.1			355.0			315.0			323.2		

LATE REPORTS FOR SAN ANTONIO, TEX.

Potential temperatures, °A.	July 1939			Aug. 1939			Sept. 1939			Oct. 1939		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature °C.
320–329										3	9.0	−38.0
330–339				2	11.2	−49.0	1	10.4	−41.0	10	11.0	−49.6
340–349	3	11.4	−46.0	6	12.3	−53.3	8	11.9	−53.4	14	12.1	−53.7
350–359	11	13.7	−62.0	12	13.8	−64.3	17	13.6	−62.1	9	13.9	−64.1
360–369	10	14.8	−66.3	15	14.9	−66.1	12	14.7	−67.3	11	14.6	−66.4
370–379	14	15.6	−68.4	8	15.6	−69.1	7	15.5	−70.3	16	15.6	−70.5
380–389	11	16.4	−70.9	15	16.3	−70.9	12	16.0	−70.9	7	16.2	−70.8
390–399	6	17.1	−72.5	4	17.1	−72.0	5	16.9	−72.4	5	17.1	−72.8
400–409	4	17.6	−70.2	3	17.3	−70.3	7	17.4	−72.0	3	17.2	−72.0
Weighted means		15.3	−66.8		15.0	−66.1		14.8	−65.8		14.0	−62.5
Mean potential temperature °A. (weighted)	372.9			369.3			368.9			361.5		

AEROLOGICAL OBSERVATIONS FOR THE YEAR 1939

[Aerological Division, D. M. LITTLE in charge]

By B. FRANCIS DASHIELL

An increase in the use of radiosondes for obtaining observations of pressure, temperature and humidity in the upper air was one of the outstanding features of the aerological work of the Weather Bureau during 1939. At the close of the year radiosonde observations were being made daily at 25 stations of the Weather Bureau, 3 of the United States Navy, and 1 of the Army. Airplane meteorological flights were conducted by the Navy at 6 stations. Valuable radiosonde data were obtained during the 1939 hurricane season at San Juan, P. R., and Swan Island. Special observations were also made by radiosonde at Boston, Mass., and St. Georges, Bermuda, under the direction of the Massachusetts Institute of Technology, and by the United States Coast Guard when on duty at Halifax, Nova Scotia, and at sea in a patrol area extending from latitudes 40° to 44° N. and longitudes 47° to 53° W. Mean pressures, temperatures and humidities, computed from the above data, have been published regularly in the MONTHLY WEATHER REVIEW.

Pilot-balloon observations of wind directions and velocities were being made 4 times daily at 98 Weather Bureau stations in the United States proper, at 4 in Alaska, and 1 in Puerto Rico. All of the above stations, with the exception of 2 in Alaska, substituted helium gas for hydrogen on July 1, 1939. A selected group of 27 stations, where afternoon visibilities were unusually favorable, have been using 100-gram pilot balloons for the 5 p. m., 75th meridian time, observations. This was an increase of 12 stations over those in operation at the beginning of the year. During 1939 pilot-balloon observations formerly made at Cleveland were transferred to Akron, Ohio; Vicksburg to Jackson, Miss.; Fort Worth to Dallas, Tex.; and Floyd Bennett Field to the New York City airport. New pilot-balloon stations were opened during 1939 at Birmingham, Ala.; Butte, Mont.; Camden, N. J.; Des Moines, Iowa; Elkins, W. Va.; Elmira, N. Y.; Hartford, Conn.; Little Rock, Ark.; Louisville, Ky.; Milwaukee, Wis.; Mobile, Ala.; Pueblo, Colo.; Rapid City, S. Dak.; San Antonio, Tex.; Springfield, Mo.; and Toledo, Ohio.

A monthly series of flights by sounding balloons carrying recording meteorographs, checked by two theodolite observations, was conducted at Omaha, Nebr., during the month of April in accordance with the international program.

The work of reducing all existing Weather Bureau pilot-balloon observations to punch cards was completed by the Works Progress Administration at its special cooperative Weather Bureau project in New Orleans, La. At the close of the year approximately one million individual flights had been reduced to cards, and the data are being summarized and combined in quickly available forms.

In the upper air, at 1.5, 3, 4, and 5 kilometers, where observations were made both by airplanes and radiosondes,

the lowest annual mean barometric pressure in the United States prevailed throughout the year over Sault Ste. Marie, Mich. This also occurred at all higher levels. Highest pressure occurred generally throughout the South, but particularly over Pensacola and Miami, Fla. These annual means are shown in table 1.

Mean relative humidity was highest over Sault Ste. Marie, Mich., at all levels; and lowest over El Paso, Tex., up to 2.5 kilometers; over San Diego, Calif., to 5 kilometers; and over Oakland, Calif., up to 7 kilometers.

The lowest annual mean temperatures for the year were recorded over Sault Ste. Marie, Mich., at 1.5, 3, 4, and 5 kilometers, while the highest were over El Paso, Tex., at 1.5 and 3 kilometers, and Pensacola, Fla., at 4 and 5 kilometers. In the levels above 5 kilometers, Sault Ste. Marine, Mich., continued to be the coldest station up to 11 kilometers, then Nashville, Tenn., became colder at all subsequent levels. Sault Ste. Marie, Mich., which was the coldest below 11 kilometers, became the warmest above 12 kilometers. The lowest annual mean temperature for 1939 was −65.7° C. over Nashville, Tenn., at 17 kilometers.

At stations having one year of radiosonde records it was found that the individual minimum temperatures noted in the higher levels occurred during different months. However, many low temperatures of interest were observed over several of the newer radiosonde stations. The lowest individual minimum temperatures recorded by radiosonde were −85.1° C. in October and −83.3° C. in August over Swan Island. Other extremely low temperatures occurred in October over San Juan, P. R. (−81.3° C.) Atlanta, Ga. (−80.6° C.), and Charleston, S. C. (−80.5° C.).

With the expansion of radiosonde activities it has been possible to make a comprehensive survey of the upper-air levels at which mean freezing temperatures (0° C.) occurred during 1939. This level reached its maximum altitude during the summer (July) sloping upward from 3,550 meters at Seattle, Wash., to 5,140 meters over San Antonio, Tex., and 5,120 meters over Pensacola, Fla. During winter (January) freezing temperatures or lower occurred at the surface at most northern stations, but in the South (Pensacola, Fla.) the monthly mean freezing level was located at 3,440 meters. A compilation of these monthly levels for all stations is shown in table 4.

During each month of the year resultant wind directions and velocities were computed for all stations in the United States at 1.5 and 3 kilometers (5 a. m.), and 4 and 5 kilometers (5 p. m.). These have been shown on charts which were published monthly. In addition, monthly wind resultants (based on 5 p. m., 75th meridian time observations) have been computed and published for all levels at 39 stations.

An annual summary of the 5 p. m. winds is shown in table 2. Individual maximum velocities reported for the different sections of the country during the year are shown in table 3. In several instances these have been very high, and a velocity of 95.5 meters per second (214 miles per hour) recorded at 8.4 kilometers over Albuquerque, N. Mex., on the 14th of January, was the highest ever obtained by pilot balloons in the upper air.

TABLE 1.—*Mean free-air barometric pressure in millibars, temperature in degrees Centigrade, and relative humidities in percent, obtained by airplanes and radiosondes during year 1939*

Altitude (meters) mean sea level	Stations and elevations in meters above sea level																											
	Billings, Mont. (1,089 m.)				El Paso, Tex. (1,198 m.)				Lakehurst, N. J.[1] (39 m.)				Nashville, Tenn. (180 m.)				Norfolk, Va.[1] (10 m.)				Oakland, Calif. (2 m.)				Oklahoma City, Okla. (391 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	361	891	6.8	60	364	882	13.8	47	315	1,013	8.7	80	363	996	12.4	80	270	1,019	13.3	82	363	1,017	10.9	84	361	970	12.8	70
500									315	957	9.5	68	363	959	13.5	71	270	961	13.9	64	362	959	11.9	74	360	957	13.9	66
1,000									314	902	7.6	65	363	904	11.6	69	270	906	11.4	60	362	903	13.2	56	360	903	14.2	57
1,500	361	848	5.7	52	364	851	15.9	42	309	848	5.7	63	363	851	9.3	66	270	853	8.9	59	362	851	11.5	48	360	851	12.2	53
2,000	360	798	6.0	52	364	802	13.2	40	306	798	3.6	61	363	801	7.1	63	269	803	6.6	56	363	801	9.1	43	361	801	9.7	51
2,500	359	750	2.8	53	364	755	10.1	40	302	750	1.3	60	363	754	4.8	59	269	755	4.1	53	363	754	6.4	41	361	754	7.0	50
3,000	358	705	−0.7	55	363	711	6.6	41	301	705	−1.2	57	359	708	2.4	56	268	710	1.4	50	363	709	3.5	39	361	709	4.2	48
4,000	358	621	−7.4	57	359	628	−0.3	43	290	621	−6.4	54	355	626	−2.9	51	263	626	−4.2	44	360	626	−2.6	37	358	626	−1.8	46
5,000	354	545	−14.2	56	356	554	−7.2	43					353	551	−8.8	48	202	551	−10.6	41	360	551	−9.0	37	355	552	−8.1	43
6,000													350	483	−14.9	46					358	484	−15.8	35	353	484	−14.7	40
7,000													347	423	−21.7	44					356	423	−23.0	34	351	424	−21.5	38
8,000													340	368	−28.7	43					349	368	−30.6	34	344	369	−28.6	37
9,000													337	320	−35.9						345	319	−38.2	33	338	320	−35.8	
10,000													335	276	−43.1						339	275	−45.4		333	277	−43.0	
11,000													327	238	−49.6						331	236	−51.7		322	238	−49.6	
12,000													314	204	−55.0						321	202	−56.3		311	204	−54.6	
13,000													304	174	−58.7						314	173	−58.7		296	174	−58.2	
14,000													300	148	−61.4						301	147	−60.3					
15,000													275	126	−63.8						282	125	−62.0					
16,000													259	107	−65.2						261	106	−63.4					
17,000													221	90	−65.7						234	90	−63.8					
18,000																					199	76	−63.1					

See footnotes at end of table.

TABLE 1.—*Mean free-air barometric pressure in millibars, temperature in degrees Centigrade, and relative humidites in percent, obtained by airplanes and radiosondes during year 1939*—Continued

Altitude (meters) mean sea level	Stations and elevations in meters above sea level																							
	Omaha, Nebr. (301 m.)				Pearl Harbor, T. H. (6 m.) [1]				Pensacola, Fla. (24 m.) [1]				San Diego, Calif. (19 m.) [1]				S. Ste. Marie, Mich. (221 m.)				Spokane, Wash. (598 m.)				Washington, D. C. (7 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	365	980	8.6	73	365	1,016	21.6	81	318	1,018	16.8	87	344	1,014	15.0	80	363	988	1.7	69	358	947	6.8	73	339	1,017	10.8	80
500	365	957	9.9	66	365	960	19.8	77	318	962	17.7	70	344	958	15.0	74	363	954	2.4	85					339	959	10.3	69
1,000	365	901	9.7	59	365	906	16.3	80	318	907	15.6	65	344	903	15.6	58	363	897	1.5	81	358	902	9.1	61	339	903	8.6	66
1,500	365	848	8.1	55	365	854	13.6	77	318	855	13.3	61	344	851	14.4	48	363	843	−0.1	78	357	848	6.8	57	339	850	6.5	64
2,000	365	798	5.7	53	365	804	12.0	63	318	805	11.2	55	344	802	12.3	42	363	792	−2.1	75	357	798	3.5	58	339	799	4.6	62
2,500	365	750	3.0	52	365	757	10.6	46	318	758	8.9	50	344	755	9.5	39	363	743	−4.2	71	354	750	0.2	59	338	751	2.2	60
3,000	365	705	0.2	51	365	713	8.4	37	318	714	6.5	46	344	710	6.5	36	363	697	−6.4	68	353	704	−3.0	59	336	706	−0.3	58
4,000	360	622	−5.8	50	363	631	2.9	28	316	631	0.7	42	333	628	0.0	34	358	613	−11.9	64	347	620	−9.0	56	335	622	−5.3	55
5,000	357	547	−12.2	49					252	556	−5.3	42					355	537	−17.8	61	319	544	−15.3	54	334	547	−10.9	52
6,000	353	479	−18.9	46													351	469	−24.2	59					331	480	−17.0	50
7,000	350	418	−26.0	44													349	408	−31.2	57					323	419	−23.5	49
8,000	349	363	−33.4														343	354	−38.1						303	365	−30.4	
9,000	348	314	−40.5														337	305	−44.6						290	316	−37.3	
10,000	343	271	−46.7														324	262	−49.6						277	273	−43.9	
11,000	339	233	−51.8														311	225	−53.1						267	235	−50.0	
12,000	332	199	−55.4														293	192	−55.1						239	201	−54.9	
13,000	322	170	−57.8														276	164	−56.0						218	172	−58.2	
14,000	309	145	−59.4														252	140	−56.6									
15,000	290	123	−61.0														225	120	−57.6									
16,000	265	105	−62.2														192	102	−58.4									
17,000	222	89	−62.3																									

Altitude (meters) mean sea level	Stations and elevations in meters above sea level							
	Coco Solo, C. Z.[1] [2] (15 m.)				Seattle, Wash.[1] [2] (10 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	296	1,011	25.6	88	244	1,018	11.8	74
500	296	957	23.3	88	244	960	9.2	73
1,000	295	904	20.7	86	244	904	7.6	66
1,500	291	853	18.3	82	219	850	5.6	61
2,000	284	804	16.1	75	211	800	3.1	56
2,500	276	758	14.4	62	196	751	0.7	52
3,000	272	715	12.3	54	190	706	−1.8	47
4,000	246	634	6.8	52	174	621	−7.7	45

[1] Navy.
[2] Yearly means based on 11 months. Month of December not included due to insufficient number of observations.

TABLE 2.—*Free-air resultant winds based on pilot-balloon observations made near 5 p. m. (E. S. T.) during 1939*

[Directions given in degrees from north (N=360°, E=90°, S=180°, W=270°)—velocities in meters per second]

Altitude (meters) m. s. l.	Abilene, Tex. (537 m.)		Albuquerque, N. Mex. (1,554 m.)		Atlanta, Ga. (302 m.)		Billings, Mont. (1,095 m.)		Boise, Idaho (850 m.)		New York, N. Y. (15 m.)		Brownsville, Tex. (7 m.)		Buffalo, N. Y. (220 m.)		Burlington, Vt. (132 m.)		Charleston, S. C. (18 m.)		Cheyenne, Wyo. (1,873 m.)		Chicago, Ill (192 m.)		Cincinnati, Ohio (167 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	189[332]	1.9	250[304]	1.5	269[345]	1.6	281[362]	2.0	296[339]	2.0	247[338]	2.2	125[340]	3.8	254[347]	3.2	246[324]	1.0	190[303]	1.2	275[344]	2.7	246[329]	1.5	248[325]	1.7
500					270[346]	2.0					267[324]	4.3	138[340]	4.9	252[347]	4.8	245[323]	2.8	209[327]	2.8					245[344]	3.0	294[318]	3.6
1,000	189[341]	2.7			263[341]	2.6			298[333]	2.2	279[313]	6.4	150[336]	3.2	252[306]	7.2	263[310]	4.9	230[313]	3.7					254[317]	4.9	247[327]	4.6
1,500	203[350]	2.9			267[327]	3.5	274[336]	3.5	296[323]	1.9	285[299]	8.1	183[279]	1.9	260[288]	7.6	270[299]	6.4	284[302]	5.3					268[288]	6.4	259[299]	5.9
2,000	227[333]	3.6	294[320]	2.3	273[299]	4.9	279[347]	4.9	291[340]	2.5	288[266]	9.4	219[229]	1.7	270[333]	8.4	281[291]	7.6	274[279]	6.5	276[344]	3.2	275[332]	7.7	271[279]	7.4
2,500	244[317]	4.4	283[301]	2.9	278[276]	6.2	279[329]	6.3	279[322]	3.7	289[236]	11.1	236[213]	2.2	277[189]	8.1	286[277]	8.5	272[255]	7.7	284[244]	4.5	282[223]	8.8	280[240]	8.1
3,000	252[304]	5.4	271[279]	3.9	282[272]	7.1	277[312]	7.9	273[213]	4.6	288[194]	11.9	251[181]	2.5					271[226]	7.7	285[240]	6.8	288[250]	9.6		
4,000	265[270]	6.9	280[226]	6.4	283[218]	8.7	282[262]	10.5	274[251]	6.2									273[170]	8.9	286[214]	8.1				
5,000	272[244]	8.7	283[204]	8.7			286[227]	12.3	265[183]	7.8											283[237]	10.0				
6,000	272[207]	9.9	283[202]	10.5			288[208]	12.8													285[210]	11.9				
8,000			276[213]	11.7																						
10,000			279[167]	15.2																						

TABLE 2.—*Free-air resultant winds based on pilot-balloon observations made near 5 p. m. (E. S. T.) during 1939*—Continued

Altitude (meters) m. s. l.	El Paso, Tex. (1,196 m.)		Fargo, N. Dak. (283 m.)		Greensboro, N. Car. (271 m.)		Havre, Mont. (766 m.)		Houston, Tex. (21 m.)		Huron, S. Dak. (393 m.)		Las Vegas, Nev. (570 m.)		Medford, Oreg. (410 m.)		Miami, Fla. (10 m.)		Minneapolis, Minn. (261 m.)		Nashville, Tenn. (194 m.)		New Orleans, La. (19 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	242[264]	1.5	290[332]	1.2	243[337]	1.5	267[340]	2.5	32[354]	2.0	285[302]	1.3	156[340]	8.1	310[349]	1.5	107[302]	2.7	260[344]	1.6	245[341]	1.3	103[356]	0.1
500			282[338]	1.7	243[337]	2.6			17[345]	2.9	290[302]	1.6			314[339]	1.8	111[302]	3.0	256[344]	2.2	236[341]	2.2	185[356]	1.5
1,000			276[315]	3.2	250[332]	4.2	261[346]	4.7	186[330]	1.8	283[306]	2.5	144[300]	7.0	296[339]	1.2	59[349]	1.6	250[332]	3.5	240[339]	3.1	224[330]	1.8
1,500	245[300]	1.8	264[316]	4.9	264[330]	5.3	269[340]	6.8	249[310]	1.6	282[322]	4.2	204[302]	8.8	246[326]	1.5	191[335]	5.5	260[315]	5.1	255[331]	4.2	271[307]	1.8
2,000	247[302]	2.2	288[305]	6.5	273[314]	7.2	275[326]	8.0	274[298]	2.4	285[314]	6.0	239[299]	1.8	259[316]	2.0	243[304]	1.1	276[279]	7.1	268[290]	5.6	288[276]	3.0
2,500	257[317]	2.7	285[279]	8.1	279[302]	8.8	277[308]	9.2	268[291]	3.2	285[300]	7.6	256[317]	2.5	240[307]	3.1	251[273]	1.7	284[302]	8.4	274[282]	6.5	280[289]	3.6
3,000	262[318]	3.6	287[307]	9.7	280[316]	10.3	276[302]	9.3	273[285]	3.8	287[292]	9.1	261[322]	3.0	249[273]	3.6	250[290]	2.1	289[318]	9.6	283[290]	7.5	294[290]	4.4
4,000	266[310]	5.6	288[311]	12.3	281[293]	12.7	281[285]	10.0	279[304]	5.4	288[291]	11.3	265[299]	4.7	254[307]	5.0	238[298]	2.8	290[289]	11.4	290[297]	9.4	291[299]	5.0
5,000	266[273]	7.4			287[289]	14.6	283[287]	11.5	280[284]	5.9	292[295]	13.5	270[310]	5.7	260[294]	6.5	244[299]	3.4						
6,000	270[299]	8.9									294[296]	14.7	277[302]	6.9										
8,000											292[276]	16.3	285[294]	8.9										
10,000													283[310]	11.5										
12,000																								
14,000																								
16,000																								
18,000																								

Altitude (meters) m. s. l.	Oakland, Calif. (8 m.)		Oklahoma City, Okla. (402 m.)		Omaha, Nebr. (306 m.)		Reno, Nev. (1,346 m.)		St. Louis, Mo. (170 m.)		Salt Lake City, Utah (1,294 m.)		San Diego, Calif. (15 m.)		San Juan, P. R. (16 m.)		Sault Ste. Marie, Mich. (198 m.)		Seattle, Wash. (14 m.)		Spokane, Wash. (603 m.)		Washington, D. C. (10 m.)		Winslow, Ariz. (1,488 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	266[340]	4.0	349[332]	1.9	249[344]	1.0	251[305]	0.9	228[340]	1.4	294[309]	1.3	278[319]	3.6	80[265]	6.0	283[310]	2.1	243[310]	1.9	221[344]	2.1	263[310]	1.1	252[263]	2.5
500	292[311]	2.5	191[348]	2.2	251[334]	1.4			236[346]	2.5			289[319]	2.3	87[265]	7.8	286[310]	3.1	217[330]	2.5			282[310]	3.1		
1,000	302[329]	1.7	207[347]	2.8	254[343]	2.4			243[323]	3.9			305[324]	0.7	105[327]	6.6	274[295]	4.0	214[289]	3.4	219[332]	3.2	263[329]	5.1		
1,500	294[326]	1.7	227[299]	3.7	264[329]	4.2	252[305]	.8	261[296]	5.3	258[310]	1.2	356[307]	0.7	107[326]	5.6	282[297]	5.2	214[289]	3.7	227[326]	4.3	277[311]	7.5		
2,000	294[310]	1.4	293[322]	4.7	268[309]	6.0	230[302]	1.4	271[296]	6.9	243[318]	1.6	330[299]	0.7	103[324]	4.9	286[323]	6.8	225[316]	3.8	237[297]	5.3	283[297]	9.5	247[281]	2.2
2,500	283[302]	1.7	255[311]	5.6	281[293]	7.8	241[310]	2.3	281[285]	8.2	245[315]	2.4	298[285]	1.1	97[310]	4.7	294[297]	8.1	235[310]	4.2	245[305]	5.8	284[309]	10.9	252[281]	2.8
3,000	294[291]	2.3	263[305]	6.7	281[273]	9.2	255[304]	3.3	286[318]	9.3	254[333]	3.3	284[309]	2.0	94[271]	4.4	295[305]	9.8	238[279]	5.0	253[295]	6.4	284[324]	11.5	250[289]	3.1
4,000	290[275]	3.2	273[271]	8.2	287[289]	11.7	267[296]	4.5			269[292]	5.1	288[296]	3.2	89[271]	3.4					264[294]	8.5	286[305]	12.4	265[329]	4.6
5,000	274[289]	1.1	281[305]	9.6	289[322]	13.3	276[275]	5.9			277[293]	6.6	265[310]	5.2							270[294]	9.8			273[301]	5.9
6,000			284[319]	11.0	292[315]	14.9	283[291]	6.8					267[289]	6.6											279[277]	7.5
8,000																									279[244]	10.4
10,000																									278[301]	13.6
12,000																									273[163]	16.1

TABLE 3.—*Maximum free air wind velocities (m. p. s.), for different sections of the United States based on pilot-balloon observations during the year of 1939*

Section	Surface to 2,500 meters (m. s. l.)						Between 2,500 and 5,000 meters (m. s. l.)						Above 5,000 meters (m. s. l.)					
	Maximum velocity	Direction	Altitude (m.) (m. s. l.)	Date	Month	Station	Maximum velocity	Direction	Altitude (m.) (m. s. l.)	Date	Month	Station	Maximum velocity	Direction	Altitude (m.) (m. s. l.)	Date	Month	Station
Northeast [1]	51.6	WNW	2,360	31	Dec.	Harrisburg, Pa.	62.8	NW	4,240	24	Oct.	Hartford, Conn.	61.0	W	9,880	13	Feb.	Cleveland, Ohio.
East-Central [2]	56.6	W	2,480	31	Dec.	Richmond, Va.	63.4	W	4,320	26	Jan.	Greensboro, N. C.	76.0	WNW	9,400	5	Dec.	Greensboro, N. C.
Southeast [3]	42.0	SW	2,440	30	Jan.	Jacksonville, Fla.	50.0	W	4,300	22	Feb.	Spartanburg, S. C.	73.0	N	20,620	8	June	Miami, Fla.
North-Central [4]	43.6	W	1,970	25	Apr.	Minneapolis, Minn.	54.4	NW	4,260	7	Dec.	Milwaukee, Wis.	75.0	NW	10,080	13	Dec.	Huron, S. Dak.
Central [5]	50.2	SW	2,320	9	Jan.	Wichita, Kans.	54.0	WSW	4,680	1	Feb.	Omaha, Nebr.	87.5	WSW	11,960	22	do.	Omaha, Nebr.
South-Central [6]	41.0	SSW	1,390	16	Feb.	Oklahoma City, Okla.	53.2	NNW	3,280	2	do.	Del Rio, Tex.	75.2	WNW	12,750	5	Nov.	Abilene, Tex.
Northwest [7]	47.7	WNW	1,700	19	May	Billings, Mont.	53.5	SW	4,500	1	Jan.	Medford, Oreg.	72.0	NNW	6,580	14	Jan.	Billings, Mont.
West-Central [8]	45.3	SSW	2,500	15	June	Modena, Utah	67.4	SW	3,960	3	June	Reno, Nev.	86.0	ENE	17,760	17	Feb.	Denver, Colo.
Southwest [9]	51.4	N	2,500	5	Apr.	Sandberg, Calif.	59.1	NNW	2,750	26	Feb.	Sandberg, Calif.	95.5	NNW	8,440	14	Jan.	Albuquerque, N. Mex.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

TABLE 4.—*Monthly mean heights of freezing temperatures (0° C.) during year 1939*

Stations	Elevation in meters (m. s. l.)	January		February		March		April		May		June		July		August		September		October		November		December	
		Number of observations	Altitude in meters (m. s. l.)	Number of observations	Altitude in meters (m. s. l.)	Number of observations	Altitude in meters (m. s. l.)	Number of observations	Altitude in meters (m. s. l.)	Number of observations	Altitude in meters (m. s. l.)	Number of observations	Altitude in meters (m. s. l.)	Number of observations	Altitude in meters (m. s. l.)	Number of observations	Altitude in meters (m. s. l.)	Number of observations	Altitude in meters (m. s. l.)	Number of observations	Altitude in meters (m. s. l.)	Number of observations	Altitude in meters (m. s. l.)	Number of observations	Altitude in meters (m. s. l.)
Albuquerque, N. Mex.	1,620															31	4,780	30	4,610	27	3,790	29	3,160	31	2,130
Atlanta, Ga.	300													26	4,740	31	4,340	28	4,480	29	4,130	30	2,670	31	2,810
Bermuda (St. Georges)	50							24	3,470	26	3,990	29	4,470												
Billings, Mont.	1,089	30	(1)	26	(1)	31	1,760	30	2,530	31	3,330	30	3,280	31	4,500	31	4,290	30	3,780	30	2,920	30	2,900	31	2,230
Bismarck, N. Dak.	505													23	4,470	30	4,210	30	3,710	30	2,500	30	2,460	31	(1)
Boise, Idaho	824																	29	3,860	30	3,000	30	2,750	30	2,160
Boston, Mass.	26							27	1,620	30	2,730														
Buffalo, N. Y.	220																	28	3,710	30	2,350	29	500	31	(1)
Charleston, S. C.	14													17	4,710	30	4,830	29	4,470	28	4,360	29	3,090	30	3,070
Cheyenne, Wyo.	1,873	31	(1)	28	(1)	30	2,410	28	2,900	30	3,780	30	4,160	15	4,870										
Chicago, Ill.	187	29	(1)	28	(1)	30	710	30	1,750	31	3,350	30	4,210												
Denver, Colo.	1,616													18	4,980	31	4,660	29	4,460	29	3,620	30	3,170	30	2,970
El Paso, Tex.	1,193	31	2,820	28	2,330	31	3,480	30	3,840	27	4,210	29	4,680	30	4,870	31	4,800	30	4,690	31	4,080	30	3,310	31	3,460
Ely, Nev.	1,908															31	4,680	28	4,130	29	3,380	30	3,200	31	2,650
Fairbanks, Alaska	152																	19	1,260	30	(1)	29	(1)	30	(1)
Fargo, N. Dak.	274	31	(1)	28	(1)	31	(1)	30	1,240	31	3,340	27	3,590												
Halifax, Nova Scotia	5									18	1,200	20	3,320												
Joliet, Ill.	178													30	4,780	29	4,320	28	4,210	29	2,960	29	1,570	31	(1)
Juneau, Alaska	49																			30	870	30	760	29	770
Lakehurst, N. J.	39	23	(1)	23	780	25	630	22	1,620	28	3,200	9	4,510	6	4,320	9	4,780	7	4,460	31	3,170	27	1,360	29	(1)
Medford, Oreg.	401																	30	3,770	31	3,430	29	3,090	30	2,470
Miami, Fla.	4													20	4,950	31	5,140	29	4,700	29	4,790	29	4,330	31	4,070
Minneapolis, Minn.	263																	30	3,710	31	2,460	30	1,630	31	(1)
Nashville, Tenn.	180	31	1,960	28	2,180	30	2,720	28	2,780	31	3,740	29	4,640	30	4,700	31	4,580	30	4,510	30	3,650	29	2,300	31	2,120
Norfolk, Va.	10	19	2,060	15	1,600	22	2,030	18	2,620	25	3,670	13	4,670	16	4,500	23	4,390	23	4,140	22	3,640	25	2,550	24	1,770
Oakland, Calif.	2	31	2,590	28	1,950	31	2,560	30	3,380	31	3,480	30	4,270	31	4,780	31	4,810	30	4,130	30	3,760	29	3,430	31	3,130
Oklahoma City, Okla.	391	30	2,260	28	1,860	31	2,920	28	3,280	31	3,930	29	4,480	31	4,820	30	4,730	29	4,660	29	3,820	30	2,870	31	2,910
Omaha, Nebr.	301	31	(1)	28	(1)	31	1,840	30	2,280	31	3,670	28	4,310	30	4,650	31	4,410	30	4,420	31	3,290	30	2,230	31	1,880
Pearl Harbor, T. H.	6	8	5,000	5	4,850																				
Pensacola, Fla.	13	25	3,440	16	3,480	21	3,580	29	3,770	20	4,150	24	5,030	22	5,120	20	4,730	20	4,580	29	4,410	27	3,590	30	3,520
Phoenix, Ariz.	339															30	4,830	29	4,710	31	4,030	29	3,530	30	3,610
St. Louis, Mo.	171																	30	4,340	30	3,350	30	2,100	31	1,720
Salt Lake City, Utah	1,288	31	(1)	28	(1)	31	2,410	30	3,100	31	3,690	30	4,030	21	4,740										
San Antonio, Tex.	174													24	5,140	29	4,950	28	4,860	31	4,620	29	3,720	31	3,710
San Diego, Calif.	10	29	2,880	29	2,420	27	3,080	27	3,790	25	4,040	27	4,760	28	4,890	29	4,850	15	4,670	8	4,210	24	3,580	27	3,710
San Juan, P. R.	18															31	4,760	28	4,780	29	4,770				
Seattle, Wash.	10	12	1,160	18	670	19	1,630	19	2,180	22	2,710	17	2,680	21	3,550			17	3,960	10	3,340	15	2,780		
Shreveport, La.	51									18	4,080											18	3,550	20	2,940
Sault St. Marie, Mich.	221	31	(1)	28	(1)	31	(1)	30	(1)	31	2,690	29	3,610	30	3,700	30	3,650	28	3,250	31	1,600	30	(1)	31	(1)
Swan Island, West Indies	10															31	4,450	27	4,370	31	4,580				
Spokane, Wash.	598	30	920	25	(1)	30	1,680	30	2,390	31	2,810	29	2,800	30	3,940	31	4,210	29	3,370	31	2,450	30	2,540	30	1,520
Washington, D. C.	7	29	800	25	1,500	31	1,670	30	2,160	29	3,150	27	4,360	26	4,250	30	4,400	25	4,300	29	3,570	27	2,000	27	1,050
At sea: (Lat. 40°–44° N., Long. 47°–53° W.)	5									30	2,900	25	3,700												

[1] Surface.

RIVERS AND FLOODS

[River and Flood Division, MERRILL BERNARD in charge]

By BENNETT SWENSON

The report for December 1939 will appear in the next issue of this REVIEW.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, W. E. HURD acting in charge]

NORTH ATLANTIC OCEAN, DECEMBER 1939

By H. C. HUNTER

Atmospheric pressure.—The pressure was below normal over most parts of the North Atlantic Ocean. The deficiency was notably large over the waters adjacent to the Canadian Maritime Provinces and to the northeastern United States.

The stations in middle and lower latitudes generally reported pressures averaging lower during the final third of the month than during the preceding portion.

The extremes of pressure found in available vessel reports are 1,038.9 and 955.9 millibars (30.68 and 28.23 inches). The high mark was recorded during the forenoon of the 13th, near latitude 40° N., 35° W., on the American steamship *Yaka*. The low reading was noted in about the same part of the ocean, namely 48° N., 33° W., about midnight of the 29th–30th, on the Dutch liner *Noordam*.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, December 1939*

Station	Average pressure	Departure	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Julianehaab, Greenland [1]	999.4	+1.1	1,019	18	985	6, 7
Lisbon, Portugal [2]	1,019.7	+.1	1,032	1	1,003	24
Horta, Azores	1,017.7	−3.0	1,033	14	991	29, 30
Belle Isle, Newfoundland [3]	1,000.5	−6.6	1,028	12	950	9
Halifax, Nova Scotia	1,006.1	−8.1	1,026	16	981	8
Nantucket	1,009.1	−8.5	1,029	15	990	8
Hatteras	1,015.2	−5.1	1,032	15	1,000	27
Turks Island	1,016.7	−0.2	1,020	26	1,011	24
Key West	1,017.6	−1.0	1,024	7	1,009	26
New Orleans	1,018.6	−1.7	1,029	14	998	26

[1] For 24 days. [2] For 27 days. [3] For 26 days.

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

208641—40——3

Cyclones and gales.—The reports available from vessels show that the month was distinctly less stormy over the North Atlantic than December usually is. No reports of hurricane-force winds (12) have been received, and only three reports of force 11.

During the first few days there were no important storms over the middle or western portions of the ocean, and cyclonic activity was not marked over any part of the North Atlantic from the 5th to the 7th, and again from the 12th to the 17th.

The first occurrence of force 11 was recorded by the Dutch motorship *Kota Tjandi*, on the 8th, about 200 miles to eastward of Cape Cod.

The other two encounters with force 11 occurred on the 23d and 25th respectively, in each case not far from the 55th meridian. The vessels which sent these reports were the Dutch steamship *Blommersdijk* and the Norwegian motorship *Nyhorn*.

The lowest barometer reading of the month was noted in connection with a rapidly moving storm which did not cause winds of force exceeding 10, so far as reports show. The center of this storm was near Cape Hatteras on the forenoon of the 27th, and 24 hours later was located not far to southward of Sable Island. A marked increase in strength occurred during the next 24 hours, as the storm advanced to about 45° N., 40° W. The center moved slightly to north of eastward to reach 46° N., 32° W., on the 30th, and then turned more to the northeastward.

Fog.—While reports of fog came from many areas, more widely scattered than usual, yet nowhere did fog occur very frequently. Two squares adjacent to the northeastern coast of the United States led in number of days, having 5 each; these are located from 35° to 40° N., 75° to 80° W.; and from 40° to 45° N., 70° to 75° W. Several other squares had fog on 4 days each, some of these being near the eastern United States coast; one on the Gulf of Mexico, 25° to 30° N., 90° to 95° W.; and one near the southern tip of the Grand Banks, 40° to 45° N., 45° to 50° W.

Fog reports from the Grand Banks area indicate that occurrences were well scattered in matter of time, but in the northern Gulf of Mexico all reports of fog were within the first 12 days, while near the coast between the Chesapeake capes and Florida there was scarcely any fog before the 20th.

Compared with normal occurrence in December, this month is indicated as having somewhat less than normal amount of fog over the Grand Banks and thence westward to Nova Scotia and eastern New England. On the other hand, there was somewhat more fog than normal in the general vicinity of Cape Hatteras.

OCEAN GALES AND STORMS, DECEMBER 1939

Vessel	Voyage		Position at time of lowest barometer		Gale began December	Time of lowest barometer, December	Gale ended December	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Millibars*					
Boschdijk, Du. S. S.	Antwerp	New York	49 21 N.	10 52 W.	1	4p, 1	1	1,007.1	SW	SW, 9	WNW	SW, 9	SW-WNW.
Do	do	do	[1]49 04 N.	20 59 W.	3	4p, 3	3	1,014.6	WSW	WNW, 9	NW	WNW, 10	WNW-NW.
Germania, Nor. M. S.	Gothenburg	Port Arthur	60 00 N.	13 15 W.	4	10p, 3	4	967.5	NNW	NNW	NNW	NNW, 9	
American Merchant, Am. S. S.	Havre	New York	49 42 N.	10 06 W.	3	6a, 4	5	1,000.7	WNW	WNW, 8	NNW	NW, 9	WNW-NW.
Jean Jadot, Belg. S. S.	Antwerp	do	[1]49 29 N.	7 29 W.	5	4a, 5	5	989.8		NW, 9	NW	NW, 9	
Jean Lafitte, Am. S. S.	Glasgow	Georgetown, S. C.	35 00 N.	66 30 W.	8	8a, 8	9	1,005.1	SW	SW, 7	NW	NW, 9	SW-NW.
Kota Tjandi, Du. M. S.	Capetown	Boston	41 27 N.	66 08 W.	8	12m, 8	9	984.9	SSW	W, 11	W	W, 11	WSW-WNW.
Charles H. Cramp, Am. S. S.	do	do	35 10 N.	38 15 W.	8	6p, 8	9	1,006.1	WSW	WSW, 10	WNW	WNW, 10	WSW-WNW.
Boschdijk, Du. S. S.	Antwerp	New York	[1]42 20 N.	52 54 W.	8	8p, 8	9	984.6	SSW	SSW, 7	WSW	W, 9	SSE-W.
Abbekerk, Du. M. S.	Capetown	Boston	[1]33 39 N.	64 56 W.	8	8p, 8	9	1,008.6	W	NW, 9	WNW	NW, 9	W-NW.
Ferncastle, Nor. M. S.	Abadan	Bergen	59 18 N.	10 12 W.	9	8p, 9	10	985.0	NE	ESE, 7	SE	E, 9	E-SE.
Jean Jadot, Belg. S. S.	Antwerp	New York	[1]46 20 N.	41 35 W.	9	6a, 10	10	989.8	SSE	NW, 5	W	W, 9	SW-NW-WSW.
American Merchant, Am. S. S.	Havre	do	41 17 N.	64 48 W.	12	12m, 12	12	990.2	NNE	NNE, 9	NNW	NNE, 9	NE-N.
Blommersdijk, Du. S. S.	Rotterdam	do	49 42 N.	6 30 W.	14	12m, 14	14	999.2	N	SE, 4	NE	N, 8	SE-N.
Pennland, Du. S. S.	Antwerp	do	48 24 N.	34 54 W.	18	9a, 18	18	[2]993.3	SSE	S, 8	W	W, 10	S-W.
Blommersdijk, Du. S. S.	Rotterdam	do	47 48 N.	32 42 W.	18	10a, 18	18	999.8	SSW	SW, 8	W	WSW, 9	SW-WSW.
Do	do	do	[1]46 22 N.	39 21 W.	19	12p, 19	21	999.6	SSW	W, 7	WNW	NW, 9	SSW-W.
Monstella, Ital. S. S.	Sines, Portugal	do	35 40 N.	67 10 W.	22	4p, 22	23	1,001.0	W	W, 10	NW	NW, 10	
Exminster, Am. S. S.	Casablanca	do	34 15 N.	54 25 W.	23	4a, 23	24	995.6	WSW	WSW, 8	WNW	W, 9	WSW-NW.
West Harshaw, Am. S. S.	Rotterdam	Norfolk	33 50 N.	54 40 W.	23	4a, 23	24	997.3	W	W, 9	NW	WNW, 10	W-WNW.
Nyhorn, Nor. M. S.	Dublin	Philadelphia	36 06 N.	50 54 W.	23	9a, 23	24	997.3		W, 10		WNW, 10	
Blommersdijk, Du. S. S.	Rotterdam	New York	42 10 N.	56 23 W.	23	12m, 23	26	981.4	N	NW, 11	NW	NW, 11	NE-NW.
Bronxville, Nor. M. S.	Gibraltar	Boston	35 47 N.	7 01 W.	24	12m, 24	25	1,007.2		S, 6		W, 8	
Atlanta City, Am. S. S.	New York	Cristobal	29 50 N.	73 27 W.	24	3p, 24	24	1,004.4	SW	SW, 8	NW	NW, 8	SW-NW.
Exminster, Am. S. S.	Casablanca	New York	33 50 N.	58 12 W.	24	4a, 25	25	986.5	SW	SW, 10	NW	SW, 10	SW-WSW.
West Harshaw, Am. S. S.	Rotterdam	Norfolk	32 55 N.	54 35 W.	25	8a, 25	25	996.3	SSW	SSW, 10	WNW	SSW, 10	SSW-WNW
Nyhorn, Nor. M. S.	Dublin	Philadelphia	36 12 N.	53 30 W.	24	9a, 25	26	990.6		WSW, 11		WSW, 11	
Aldecoa, Span. S. S.	Ceuta	Galveston	29 20 N.	94 38 W.	25	1a, 26	26	1,011.4	NE	N, 9	NW	NE, 9	NE-NW.
Express, Am. S. S.	Lisbon	New York	[1]40 24 N.	35 08 W.	28	8a, 29	31	986.8	SW	W, 9	WNW	WNW, 10	SW-W.
Noordam, Du. M. S.	Rotterdam	do	48 00 N.	32 48 W.	28	12p, 29	31	955.9	S	NE, 6	W	NW, 9	E-NE-W.
Bronxville, Nor. M. S.	Gibraltar	Boston	33 11 N.	31 30 W.	29	10a, 30	31	1,003.2	WNW	WNW, 7	NW	WNW, 9	
Express, Am. S. S.	Lisbon	New York	[1]40 04 N.	39 56 W.	31	2p, 31	[3]1	979.0	W	SW, 2	WNW	W, 10	S-W.
Spidoleine, Belg. M. S.	Antwerp	Philadelphia	42 30 N.	46 48 W.	31	4p, 31	[3]1	975.5	W	W, 9	WNW	W, 9	
NORTH PACIFIC OCEAN													
Beaver, U. S. S.	Honolulu	Manila	12 48 N.	122 42 E.	1	4p, 2	3	994.9	NE	N, 9	NW	NNW, 9	NW-N-NNW.
Kiyo Maru, Jap. M. S.	Kobe	Los Angeles	39 36 N.	164 24 W.	[4]30	1p, 2	5	989.3	SW	W, 8	SW	W, 8	
Niel Maersk, Dan. M. S.	Yokohama	do	46 36 N.	178 48 W.	[4]30	1p, 1	2	981.4	SW	WNW, 7	NNW	WSW, 11	W-WNW.
Daisan Ogura Maru, Jap. S. S.	do	San Francisco	40 30 N.	170 00 W.	1	1a, 2	3	991.5		W, 9	WNW	W, 9	
San Clemente Maru, Jap. M. S.	do	do	45 20 N.	176 11 E.	1	12m, 2	2	988.5	W	W, 7	W	W, 9	W-NNW.
Brajara, Nor. M. S.	San Luis	Yokohama	33 36 N.	148 36 W.	4	2p, 6	6	999.4	SSW	W, 7	SW	SW, 8	SW-W.
City of Elwood, Am. M. S.	Hong Kong	Los Angeles	34 39 N.	163 00 W.	6	4p, 6	7	996.6	WSW	WSW, 7	W	WNW, 10	WSW-NW.

See footnotes at end of table.

OCEAN GALES AND STORMS, DECEMBER 1939—Continued

Vessel	Voyage		Position at time of lowest barometer		Gale began December	Time of lowest barometer, December	Gale ended December	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH PACIFIC OCEAN—Contd.								*Millibars*					
Arizonan, Am. S. S.	Los Angeles	Balboa	15 15 N.	95 00 W.	6	3a, 7	7	1,001.6	NE.	N, 6	NNW.	NNE, 8	NE-NNW.
Teal, U. S. S.	North Bend	Seattle	[1] 48 30 N.	124 40 W.	7	2p, 7	7	1,001.0	SSE.	SSE, 5	SSE.	SSE, 10	
Swiftsure Bank Lightship, U. S.	On station		48 33 N.	125 00 W.	7	4p, 7	7	997.0		SE, 9		SE, 9	
Marchen Maersk, Dan. M. S.	Los Angeles	Yokohama	34 30 N.	146 40 W.	6	9a, 7	9	996.5	SW.	SSW, 8	NNW.	NW, 10	SSW-W.
Kaizyo Maru, Jap. M. S.	do	Tokuyama	32 42 N.	155 27 W.	7	1a, 8	8	1,001.0	W.	W, 8	NW.	WNW, 8	
Kansan, Am. S. S.	Bellingham	Los Angeles	[1] 48 24 N.	124 57 W.	8	10a, 8	8	986.1	SE.	SE, 9	S.	S, 10	SE-S.
Brajara, Nor. M. S.	San Luis	Yokohama	32 54 N.	153 24 W.	7	2p, 7	8	1,002.1	NW.	WNW, 7	NW.	NW, 9	W-NW.
Madoera, Du. M. S.	Cebu	Los Angeles	17 46 N.	137 00 E.	6	5p, 8	9	995.2	NNW.	ESE, 8	ESE.	ENE, 9	
Mauna Loa, Am. S. S.	Portland, Ore.	Honolulu	30 06 N.	143 30 W.	9	3p, 8	9	1,007.8	NW.	WSW, 5	NW.	NW, 8	
Huguenot, Am. S. S.	Los Angeles	Seattle	40 49 N.	124 48 W.	9	10p, 9	9	999.3	S.	SSE, 11	W.	SSE, 11	SE-SSE-W.
Manulani, Am. S. S.	do	Honolulu	30 30 N.	133 18 W.	9	6p, 9	10	1,003.7	SSW.	SSW, 8	WNW.	W, 8	SSW-WNW.
Svealborg, Swed. M. S.	Genzan	San Luis	44 07 N.	175 14 E.	9	9p, 9	11	991.9	S.	S, 9	WNW.	WNW, 11	S-W.
do	do	do	41 18 N.	166 00 W.	11	1a, 12	12	989.2	SSE.	SW, 9	SW.	S, 11	SSE-SW.
Marchan Maersk, Dan. M. S.	Los Angeles	Yokohama	34 12 N.	174 48 W.	10	1p, 12	12	1,009.5	WNW.	WSW, 6	SW.	SSW, 9	SW-W.
S. C. T. Dodd, Am. S. S.	Vladivostok	San Francisco	40 51 N.	154 11 E.	11	Noon, 11	15	992.2	WNW.	NW, 8	NW.	W, 12	SSE-NW-W.
Corneville, Nor. M. S.	Hong Kong	Los Angeles	[1] 38 40 N.	176 07 E.	11	2p, 12	13	997.6	S.	W, 7	W.	SW, 11	
Geflon, Nor. M. S.	Yokohama	Estero Bay	39 36 N.	173 06 E.	12	8p, 12	14	997.0	W.	W, 9	WNW.	W, 10	
Daiiti Ogura Maru, Jap. M. S.	do	Los Angeles	39 50 N.	169 10 W.	12	4p, 13	15	[2] 982.4	WNW.	W, 9	WNW.	W 10	None.
Syoyo Maru, Jap. M. S.	Los Angeles	Genzan	36 42 N.	178 54 W.	11	12a, 12	15	999.7	SW.	WSW, 4	WNW.	WNW, 10	SW-WSW.
Huguenot, Am. S. S.	Seattle	Portland, Ore.	47 44 N.	124 46 W.	14	12m, 14	15	997.0	SSE.	ESE, 8	SW.	SE, 9	S-ESE-SSW.
Hokuroku Maru, Jap. M. S.	Yokohama	San Francisco	41 40 N.	154 30 E.	14	6a, 15	17	994.0	SE.	NW, 8	W.	NW, 9	
S. C. T. Dodd, Am. S. S.	Vladivostok	do	39 21 N.	179 00 W.	15	2p, 15	16	984.8	ESE.	W, 9	NNW.	W, 10	SW-W.
Marchen Maersk, Dan. M. S.	Los Angeles	Yokohama	34 10 N.	171 52 E.	15	10p, 15	16	1,003.5	S.	W, 9	NNW.	WNW, 10	S-WNW.
Columbia Maru, Jap. M. S.	Hakodate	Los Angeles	40 08 N.	166 34 E.	15	4a, 16	17	994.9	W.	W, 11	NW.	NW, 12	None.
Syoyo Maru, Jap. M. S.	Los Angeles	Genzan	38 12 N.	174 18 E.	16	3a, 16	17	984.4	WSW.	W, 9	WNW.	WNW, 11	SW-WNW.
Hokuroku Maru, Jap. M. S.	Yokohama	San Francisco	47 12 N.	171 30 W.	18	1a, 19	18	963.8		ENE, 4		E, 9	
S. C. T. Dodd, Am. S. S.	Vladivostok	do	38 47 N.	159 10 W.	18	6a, 19	19	1,000.0	S.	S, 8	WSW.	S, 10	S-SW.
Makiki, Am. S. S.	Seattle	Honolulu	46 00 N.	129 55 W.	17	10p, 18	20	1,004.7	SSE.	S, 4	W.	W, 9	SSE-S.
S. C. T. Dodd, Am. S. S.	Vladivostok	San Francisco	38 35 N.	152 30 W.	20	4p, 20	20	997.3	S.	SSE, 12	SSE.	SSE, 12	SSE-SSW.
Hokuroku Maru, Jap. M. S.	Yokohama	do	47 00 N.	158 00 W.	20	2p, 20	21	960.4		SE, 6		SW, 9	
Makiki, Am. S. S.	Seattle	Honolulu	38 35 N.	138 25 W.	21	11p, 21	22	1,014.6	SSE.	SW, 4	Var.	S, 8	S-SW.
Do.	do	do	31 00 N.	142 52 W.	23	10a, 24	24	1,005.1	SE.	S, 8	W.	SW, 9	S-WSW.
Hikawa Maru, Jap. M. S.	Yokohama	Vancouver	50 00 N.	138 57 W.	25	2p, 24	25	994.2	SSE.	SE, 7	SSE.	SSE, 8	SE-S.
Aobasan Maru, Jap. M. S.	do	San Francisco	46 15 N.	149 34 W.	26	12m, 26	26	971.3	ENE.	NW, 8	W.	ENE, 9	N-W.
Do.	do	do	42 42 N.	135 24 W.	28	3p, 28	28	982.4		SSE, 8		SSE, 8	
Skjelbred, Nor. M. S.	Masinloc, P. I.	Los Angeles	33 37 N.	145 49 W.	28	8p, 29	30	990.7	SSE.	SW, 8	WSW.	WSW, 8	SE-SW.
San Simeon, Am. S. S.	Portland, Ore.	Seattle	48 20 N.	125 10 W.	30	6a, 31	31	998.6	NE.	ENE, 8	SE.	NE, 8	NE-SE.
Matsonia, Am. S. S.	Los Angeles	Honolulu	[1] 27 13 N.	143 59 W.	31	[3] 4p, 2	[3] 2	1,004.4	SW.	W, 8	W.	SSW, 9	SSW-W.

[1] Position approximate. [2] Barometer uncorrected. [3] January. [4] November.

NORTH PACIFIC OCEAN, DECEMBER 1939

By WILLIS E. HURD

Atmospheric pressure.—Subnormal pressures, on the average, covered the northern and eastern parts of the ocean. The abnormality was most pronounced, however, in the extreme northeastern part, from the central Aleutian region eastward across the Gulf of Alaska. The center of the Aleutian LOW was not far from Kodiak, where the average pressure, 986.9 millibars (29.14 inches), was 14.1 millibars (0.42 inch) below the normal of the month. This average barometer at Kodiak is the lowest of record for December at the station during the past 14 years.

The North Pacific anticyclone was much restricted this month, and, on the average, extended as a narrow belt from the central California coast southwestward to Midway Island, then westward to the China coast. The continental Asiatic anticyclone was abnormally developed for December over the oceanic extent eastward to the Ogasawara Islands. At Naha, in the Nansei group, the average pressure was 1,022.8 millibars (30.20 inches), which was 7.6 millibars (0.22 inch) above the normal of the month.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, December 1939, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Point Barrow	1,008.5	−8.3	1,023	28	996	14
Dutch Harbor	992.3	−8.7	1,012	31	969	1
St. Paul	998.8	−2.9	1,019	31	981	21
Kodiak	986.9	−14.1	1,004	31	967	21
Juneau	999.7	−9.1	1,023	21	973	3
Tatoosh Island	1,012.2	−2.4	1,030	21	986	10
San Francisco	1,019.6	−0.4	1,027	20	1,005	23
Mazatlan	1,013.0	−0.5	1,017	29, 30	1,010	19
Honolulu	1,015.9	−0.4	1,020	12	1,008	27
Midway Island	1,017.5	+1.2	1,027	8	1,006	28
Guam	1,010.5	−1.0	1,016	31	998	22
Manila	1,011.2	0.0	1,016	12, 25–27, 29	999	3
Hong Kong	1,022.7	+3.7	1,026	27, 28	1,018	9
Naha	1,022.8	+7.6	1,027	11, 13	1,017	9, 22
Titijima	1,018.9	+3.0	1,029	28	1,011	23
Petropavlovsk	1,002.4	−0.7	1,016	14	984	27

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

Extratropical cyclones and gales.—Numerous cyclones crossed the northern waters of the ocean during December 1939, and the result was a month of frequent storminess in most areas north of the thirtieth parallel. In several instances the principal heavy gales reported occurred far to the southward of the storm centers. Winds of the higher velocities—forces 11 to 12—were encountered on 7 days, with an almost ocean-wide distribution between about latitudes 35° and 45° N. The dates of their occurrences were the 2d, 9th, 10th, 11th, 12th, 16th, and 20th. On a number of other dates gales were reported of force as high as 10.

As an indication of the widespread nature of the month's storminess, it may be mentioned that the American steamer *S. C. T. Dodd*, while on a voyage from Vladivostok toward San Francisco, ran into gales on December 11, near 41° N., 153° E., and thereafter had stormy weather daily until the 20th, inclusive, when near 39° N., 152° W. During this period she encountered hurricane velocities on the 12th, near 41° N., 160° E., and on the 20th, near 39° N., 153° W. The Danish motorship *Marchen Maersk*, while on a voyage from Los Angeles toward Yokohama, had frequent gales, highest force 10, from the 6th to 16th, between about 35° N., 143° W., and 34° N., 170° E.

Off the western coast of the United States important gales were noted near Washington on the 7th, 8th, 14th, 19th, and 31st, and near California on the 9th.

Tropical cyclones and gales.—Press dispatches and two vessel reports indicate two typhoons noted over and near the Philippine Islands. The earlier of these was felt from the 2d to the 8th, and was of marked severity. About 40 lives are indicated as lost either at sea or as a result of landslides and floods, and there was great damage to small boats, property, and crops.

The second storm, about a fortnight later, resulted in serious losses because of heavy rains in northern Luzon.

A Tehuantepecer was encountered on the night of the 6th, 7th, the greatest wind force being 8.

Fog.—There was fog on 8 days off the California coast and on 3 days off Lower California. To the southwestward of the Isthmus of Tehuantepec and the coast of Central America a little fog occurred within the period 23d-26th.

Over the western North Pacific fog was reported a few times, between latitudes 30° and 47° N. Both the localities of occurrence and the dates were widely scattered.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

TABLE 1.—*Condensed climatological summary of temperature and precipitation by sections, December 1939*

[For description of tables and charts, see REVIEW, January, p. 29]

Section	Temperature								Precipitation					
			Monthly extremes								Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	49.7	+2.2	Millry	85	10	Florence	15	30	3.29	−2.12	Dadeville	5.27	Addison	1.95
Arizona	47.5	+4.8	Florence	91	7	Pinedale	−13	26	.34	−.88	Alpine	1.65	8 stations	.00
Arkansas	45.5	+2.7	4 stations	84	7	Lead Hill	5	29	2.46	−1.76	Crossett	5.53	Hot Springs	.81
California	49.2	+3.5	2 stations	91	4	Tamarack	−8	25	2.46	−1.23	Upper Mattole	29.99	6 stations	.00
Colorado	32.3	+6.6	do	83	11	Hayden	−31	28	.46	−.44	Columbine	1.96	Redvale	.00
Florida	59.2	−.5	Okeechobee	88	2	Mason	22	30	2.15	−.57	Vernon	7.97	Everglades	.00
Georgia	48.6	+.9	Moultrie	80	19	Blairsville	13	22	3.28	−.94	Milledgeville	6.23	Mount Vernon	1.50
Idaho	34.1	+7.8	2 stations	74	[1] 10	Island Park Dam	−22	28	2.41	+.37	Deception Creek	11.51	Challis	T
Illinois	35.7	+4.7	Sparta	74	9	3 stations	−8	31	1.12	−1.00	McLeansboro	2.81	2 stations	T
Indiana	35.4	+3.2	Johnson	71	10	Marengo	−6	25	1.30	−1.50	Newburg	2.58	Rochester	.63
Iowa	32.4	+8.3	Thurman	74	6	2 stations	−9	31	.62	−.55	Red Oak	1.49	Maquoketa	.07
Kansas	39.0	+5.9	2 stations	86	6	do	−13	[1] 27	.81	−.03	Elkhart	1.20	Stockton	.36
Kentucky	38.8	+1.1	3 stations	72	[1] 7	Quicksand	−2	25	2.32	−1.54	Stearns	4.10	Cynthiana	1.15
Louisiana	55.4	+3.0	New Orleans[2]	85	10	Urania	21	30	4.15	−1.14	Robeline	9.64	Carville	1.23
Maryland-Delaware	37.8	+2.4	6 stations	70	10	Oakland, Md	4	15	1.84	−1.48	Friendsville, Md	2.80	Solomons, Md	.94
Michigan	30.8	+5.8	5 stations	58	[1] 9	Watersmeet	−12	24	1.45	−.60	Deer Park (near)	3.21	Yale	.17
Minnesota	26.4	+10.7	Wheaton	74	9	Park Rapids	−17	30	.41	−.36	Red Wing	1.25	Argyle	T
Mississippi	50.1	+1.8	3 stations	82	[1] 7	Rochdale	18	30	4.08	−1.18	Natchez	7.13	2 stations	2.22
Missouri	38.8	+4.6	Lebanon	80	10	Fulton	−5	31	1.45	−.69	Ozark Beach	2.61	do	.48
Montana	32.0	+8.7	2 stations	78	5	Outlook	−24	28	1.07	+.10	Trout Creek (near)	6.21	Helena Valley	.06
Nebraska	34.7	+7.7	Loup City	83	6	2 stations	−17	[1] 27	.70	+.02	Ashland	2.12	2 stations	.25
Nevada	39.0	+7.9	2 stations	80	[1] 4	Beowawe	−15	25	.42	−.56	Lewers ranch	1.80	do	.00
New England	27.1	+.5	Fitchburg, Mass	64	1	Enosburg Falls, Vt.	−21	27	3.08	−.26	Machias, Maine	5.85	Woodstock, Vt.	1.44
New Jersey	35.2	+1.5	Pleasantville	69	10	Layton	−1	28	1.54	−2.11	Belvidere	3.02	Pemberton	.91
New Mexico	38.0	+3.9	2 stations	84	[1] 10	Gavilan	−29	27	.65	−.03	Redrock	2.26	2 stations	.05
New York	28.2	+1.4	Jamestown	62	10	Stillwater Reservoir	−29	27	2.86	−.05	Bonaparte	5.97	Peru	1.09
North Carolina	42.8	−.3	Greenville	77	11	Mount Mitchell	6	30	2.52	−1.29	Highlands	4.44	Jefferson	1.45
North Dakota	26.7	+13.7	New England	70	5	2 stations	−20	28	.28	−.21	Carson	.78	4 stations	T
Ohio	35.0	+3.3	2 stations	69	[1] 18	4 stations	0	31	1.46	−1.27	Demos	2.36	Holgate	.57
Oklahoma	45.3	+5.3	do	86	[1] 10	Boise City	−9	26	1.09	−.54	Pawhuska	2.45	Fort Reno	.47
Oregon	39.3	+5.8	Pilot Rock	77	5	Seneca	−7	25	5.53	+1.70	McNamurs	24.91	Unity	.78
Pennsylvania	33.9	+2.6	2 stations	68	[1] 18	Gouldsboro	−8	28	2.24	−.84	Kane Forest Station	4.47	Phila. Point Breeze	.93
South Carolina	46.8	+.2	Ferguson	79	8	Caesars Head	17	30	2.75	−.79	Clemson College	4.73	Charleston	1.39
South Dakota	31.8	+10.0	2 stations	79	[1] 5	Mellette	−18	29	.29	−.25	Harveys Ranch	1.36	Fairfax	.03
Tennessee	42.2	+1.5	Milan	78	7	Crossville	10	22	3.28	−1.24	Milan	4.70	Madison College	1.85
Texas	52.4	+3.5	3 stations	94	10	Muleshoe	−9	27	1.65	−.63	Nacogdoches	9.05	Van Horn	.09
Utah	34.2	+7.3	Springdale (Zion Park)	75	5	Heber	−23	28	.40	−.68	Timpanogos Summit	2.50	4 stations	.00
Virginia	39.5	+1.5	Kenbridge	75	20	Glen Lyn	5	25	1.90	−1.16	Pinnacles	3.73	Langley Field	.69
Washington	38.9	+6.5	Sedro Woolley	74	5	Stockdill Ranch	−3	24	7.54	+2.27	Cushman Dam	35.29	Prosser (near)	1.14
West Virginia	36.6	+2.0	Logan	75	7	Seneca State Forest	−4	31	2.46	−.83	Pickens No. 2	4.74	Petersburg	.66
Wisconsin	28.9	+8.3	Beloit	65	9	Mather	−12	31	.84	−.46	Rest Lake	2.71	Darlington	.09
Wyoming	30.0	+8.0	2 stations	78	[1] 5	West Yellowstone	−34	28	.41	−.33	Snake River	2.43	Kemmerer	T
Alaska (November)	9.9	−3.2	do	58	[1] 1	Allakaket	−58	27	3.13	+.38	Little Port Walter	3.83	Council	T
Hawaii	70.1	+.1	do	89	[1] 29	Kanalohuluhulu	36	25	4.03	−4.97	Pauohakamoa No. 2	30.20	3 stations	.00
Puerto Rico	74.7	+.5	do	92	[1] 21	2 stations	54	[1] 20	3.70	−.85	La Mina (El Yunque)	14.11	Mona Island (Light House)	.66

[1] Other dates also.

[2] Audobon.

TABLE 2.—*Climatological data for Weather Bureau stations, December 1939*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*°F.*	*°F.*		*°F.*	*°F.*	*°F.*	*°F.*	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
New England							30.4	+1.0										73	2.88	−0.5										6.7		
Eastport	75	67	85	29.64	29.73	−0.25	27.2	+0.9	53	3	34	1	27	20	28	25	20	75	3.71	0.0	14	13.0	nw.	38	e.	20	8	3	20	7.2	16.5	10.8
Greenville, Maine	1,009	4	41																												
Portland, Maine	103	82	117	29.65	29.78	−.25	29.0	+1.4	53	3	36	3	27	22	21	25	19	69	4.16	+.2	10	8.8	nw.	31	s.	3	13	9	9	5.0	10.2	6.7
Concord	288	54	72	29.48	29.80	−.26	27.4	+.6	57	3	36	3	28	19	32				2.58	−.6	11	6.4	nw.	28	nw	8	8	6	17	6.7	9.2	3.5
Burlington	403	11	48	29.35	29.82	−.23	23.4	−1.0	47	2	30	−9	28	17	27	22	17	78	1.75	−.1	13	10.4	s.	34	s.	7	4	2	25	8.4	6.6	1.0
Northfield	876	12	60	28.84	29.82	−.23	21.4	+1.0	47	1	29	−17	28	14	30	19	17	85	2.35	−.1	20	7.2	n.	25	se.	7	5	3	23	7.7	9.4	5.9
Boston [1]	20	33	62	29.76	29.79	−.26	33.4	+.9	57	1	40	6	27	26	24	29	22	65	2.91	−.5	8	12.4	w.	41	nw.	8	7	6	18	6.7	6.5	4.0
Nantucket	12	14	90	29.78	29.80	−.25	36.2	+.4	57	1	42	12	27	30	22	33	29	77	2.05	−1.7	10	15.4	w.	41	n.	11	4	13	14	6.7	4.5	2.6
Block Island	26	11	46	29.79	29.82	−.24	35.8	−.2	57	20	42	10	27	30	24	33	27	71	1.60	−2.2	6	19.3	nw.	56	nw.	8	11	8	12	5.2	3.0	2.0
Providence	160	215	251	29.75	29.82	−.24	34.0	+2.4	56	20	41	5	27	27	25	29	23	72	3.12	−.3	7	12.5	nw.	49	nw.	8	7	7	17	6.5	6.5	3.5
Hartford	159	66	100	29.81	29.83	−.24	32.3	+2.5	55	2	40	7	27	25	29	27	22	72	3.79	−.2	11	9.2	nw.	35	nw.	8	6	7	18	7.0	9.3	2.5
New Haven	106	74	153	29.83	29.85	−.22	34.2	+1.7	57	10	41	7	27	27	24	29	23	69	3.71	−.3	9	9.5	nw.	31	nw.	8	8	10	13	6.1	4.6	1.8
Middle Atlantic States							37.4	+1.8										69	1.74	−1.5										6.4		
Albany [1]	292	26	40	29.51	29.84	−.24	27.0	−1.5	48	3	34	0	27	20	25	24	19	73	1.53	−1.1	11	10.7	nw.	35	nw.	14	4	8	19	7.4	4.8	1.7
Binghamton	871	57	79	29.82	29.87	−.22	30.0	+1.8	54	7	37	−3	28	23	31	27	25	76	2.12	−.2	17	7.7	nw.	28	nw.	7	1	7	23	8.5	3.9	.5
New York	314	415	454	29.51	29.86	−.23	36.2	+1.2	59	15	43	12	28	29	29	32	24	62	1.22	−2.4	8	18.1	nw.	60	nw.	8	8	9	14	6.3	3.8	1.9
Harrisburg [1]	351	30	49	29.53	29.92	−.20	35.8	+3.1	62	10	42	12	31	30	28	32	26	69	1.90	−1.1	9	9.8	w.	34	nw.	8	4	8	19	7.5	5.3	2.7
Philadelphia	114	174	367	29.77	29.90	−.21	38.1	+1.8	63	10	44	17	27	32	30	34	28	68	1.18	−2.2	8	13.3	nw.	40	nw.	11	6	9	16	6.5	2.9	.7
Reading	323	283	306	29.55	29.91	.....	36.6	+4.4	62	10	42	15	27	31	28	32	24	61	2.70	−.9	9	13.2	nw.	44	nw.	8	3	11	17	7.3	6.5	2.5
Scranton	805	72	104	29.99	29.88	−.22	31.6	+.9	53	7	38	5	28	28	33	29	23	71	2.58	−.4	12	7.8	nw.	32	nw.	7	3	10	18	7.3	9.4	1.0
Atlantic City	52	37	172	29.84	29.90	−.20	39.1	+2.7	61	10	46	18	27	33	26	35	29	71	1.33	−2.6	8	16.6	w.	45	nw.	8	9	12	10	5.8	5.6	2.0
Sandy Hook	22	10	57	29.85	29.87	.....	36.0	+.8	58	10	42	14	27	30	24	33	28	73	1.01	−3.0	8	16.6	w.	51	nw.	8	6	12	13	6.5	2.8	2.0
Trenton	190	89	107	29.68	29.89	.....	36.0	+1.6	61	10	43	14	27	29	26	32	25	67	1.49	−1.9	12	9.7	nw.	31	nw.	8	6	10	15	6.6	4.9	2.4
Baltimore [2]	123	100	215	29.92	29.93	−.20	40.8	+3.6	70	10	47	20	27	34	28	33	28	69	1.87	−1.5	10	11.6	sw.	40	nw.	8	9	8	14	6.2	6.9	3.3
Washington	112	62	88	29.81	29.94	−.19	40.1	+3.5	67	10	47	21	28	33	30	34	26	61	2.20	−1.1	11	7.6	nw.	34	nw.	22	6	12	13	6.1	4.4	1.0
Cape Henry	18	8	54	29.93	29.95	.....	43.6	−.1	69	19	51	22	25	37	30	38	34	73	1.60	−1.8	9	12.9	sw.	40	nw.	11	12	11	8	5.1	1.8	.0
Lynchburg	686	144	184	29.23	29.99	−.15	42.4	+2.9	72	18	51	22	15	34	37	35	27	61	2.11	−1.2	9	8.3	n.	35	nw.	8	11	9	11	5.3	5.9	.0
Norfolk	91	80	125	29.87	29.97	−.16	44.4	+1.3	69	19	52	21	25	37	25	38	33	71	1.15	−2.2	8	10.0	w.	32	nw.	2	9	9	13	5.6	3.3	.0
Richmond [2]	144	11	52	29.78	29.96	−.18	41.4	+1.6	69	19	51	19	25	32	35	34	29	72	1.50	−1.8	9	8.5	sw.	30	w.	21	15	8	8	4.6	3.3	T
Wytheville	2,304	49	55	27.55	30.00	−.15	37.0	+1.7	66	18	45	17	25	28	40	32	27	75	2.09	−.8	11	8.8	w.	34	w.	7	8	7	16	6.3	1.8	2.5
South Atlantic States							48.3	+0.9										73	2.33	−1.1										4.5		
Asheville	2,253	89	104	27.64	30.06	−.10	40.0	+2.2	70	7	50	20	22	30	42	33	28	68	2.08	−1.1	10	8.7	nw.	34	nw.	10	10	11	10	5.2	4.4	.0
Charlotte [2]	779	63	86	29.19	30.00	−.16	45.2	+2.2	70	18	54	28	25	36	32	37	32	73	2.56	−1.3	12	7.4	sw.	30	nw.	10	10	13	8	5.1	T	.0
Greensboro [1]	886	6	56	29.05	30.01	.....	40.5	.....	71	18	51	19	25	30	40	34	30	76	2.84	.....	11	8.0	sw.	26	nw.	2	11	10	10	5.1	1.0	.0
Hatteras	11	5	50	29.97	29.98	−.15	48.5	−1.6	67	19	54	32	25	42	26	44	41	78	3.01	−1.2	9	14.5	w.	41	n.	24	14	7	10	4.9	.0	.0
Raleigh	376	103	146	29.61	30.00	−.15	44.7	+1.7	70	18	53	27	25	36	28	37	32	73	2.24	−1.3	12	9.2	w.	25	nw.	11	10	11	10	5.1	1.0	.0
Wilmington	72	73	107	29.94	30.02	−.13	48.2	−.9	73	19	58	25	25	39	30	43	39	77	1.56	−1.2	9	8.8	nw.	39	sw.	13	14	7	10	4.5	.0	.0
Charleston [2]	48	11	92	29.99	30.04	−.11	51.4	−.3	70	10	60	33	25	43	25	46	41	75	1.39	−1.3	8	9.5	sw.	26	e.	26	18	4	9	3.8	.0	.0
Columbia, S. C.	347	70	91	29.79	30.03	−.13	48.3	+1.1	74	18	58	28	25	38	35	40	34	72	2.18	−.8	9	8.6	sw.	27	sw.	2	13	8	10	4.6	.0	.0
Greenville, S. C.	1,040	70	78	28.89	30.01	.....	45.4	+3.2	71	18	55	26	30	35	34	38	32	67	4.36	−.5	10	7.1	sw.	24	sw.	20	16	8	7	4.3	T	.0
Augusta [2]	182	62	77	29.57	30.03	−.13	48.5	+.4	74	18	60	27	25	38	38	40	34	65	2.42	−.8	8	5.5	nw.	22	w.	2	18	3	10	4.2	.0	.0
Savannah [2]	65	73	152	29.99	30.05	−.10	54.1	+1.7	76	18	65	31	30	44	32	44	40	80	1.74	−1.2	6	11.0	w.	26	w.	31	20	4	7	3.4	.0	.0
Jacksonville	43	86	110	30.02	30.06	−.08	56.8	+.5	77	19	67	33	30	46	29	50	46	76	2.13	−.9	7	7.9	w.	22	w.	27	15	8	8	4.1	.0	.0
Florida Peninsula							66.4	−0.1										82	2.65	+0.8										3.7		
Key West [2]	21	10	64	30.05	30.05	−.03	69.4	−.9	81	2	76	54	31	63	21	65	63	83	3.70	+2.0	5	8.4	ne.	26	n.	30	15	12	4	3.6	.0	.0
Miami	23	124	168	30.03	30.06	−.05	67.9	−.1	82	20	73	47	31	60	24	61	58	77	3.22	+1.5	5	8.3	n.	26	sw.	29	15	9	7	4.2	.0	.0
Tampa [2]	35	88	197	30.06	30.07	−.05	61.8	+.7	79	19	71	41	31	53	27	55	53	84	1.02	−1.0	7	10.2	n.	30	n.	29	20	5	6	3.4	.0	.0
East Gulf States							52.2	+2.2										77	3.53	−1.3										4.6		
Atlanta [1]	976	5	72	29.00	30.04	−.12	45.6	+.9	72	7	56	24	30	36	37	42	34	70	3.10	.....	7	10.1	nw.	32	e.	26	16	5	10	4.5	T	.0
Macon [2]	370	70	87	29.54	30.04	−.12	48.8	+1.3	75	7	60	26	15	38	42	41	36	72	4.92	+.9	9	6.3	nw.	22	nw.	23	15	5	11	4.7	.0	.0
Thomasville	273	49	58	29.78	30.09	−.06	55.1	+2.6	77	7	66	28	30	44	31	46	41	...	2.04	−1.3	6	.....	.....	.....	.....	.....	19	6	6	.....	.0	.0
Apalachicola	35	11	51	30.03	30.07	.....	56.6	+.9	78	11	65	35	30	48	27	51	49	82	3.49	−1.6	8	7.6	nw.	24	e.	26	12	9	10	4.6	.0	.0
Pensacola	56	149	185	30.01	30.07	−.08	55.8	+1.8	77	8	64	33	30	47	25	51	48	82	2.86	−1.8	7	7.5	w.	35	s.	26	16	9	6	3.8	.0	.0
Anniston	741	9	.....	.....	.....	.....	46.6	+2.4	70	18	57	22	30	36	38	...	...	...	3.91	−1.1	8	.....	nw.	.....	.....	.....	15	6	10	.....	T	.0
Birmingham [2]	630	5	55	29.39	30.07	−.09	48.8	+2.4	76	7	58	23	30	40	28	39	35	77	2.82	−2.3	6	7.1	w.	29	se.	23	16	5	10	4.7	T	.0
Mobile	57	86	161	30.04	30.08	−.07	54.8	+2.6	75	1	64	32	30	45	30	48	45	84	2.55	−2.5	5	8.9	nw.	33	e.	26	12	9	10	4.8	.0	.0
Montgomery [2]	218	92	105	29.80	30.06	−.10	51.6	+2.2	77	7	62	28	30	42	34	42	36	72	3.23	−1.6	6	6.7	w.	26	se.	26	16	5	10	4.4	.0	.0
Meridian [2]	375	67	92	29.73	30.07	−.09	50.6	+2.9	78	7	62	23	30	40	38	41	38	82	5.19	.0	7	5.6	w.	23	w.	13	15	3	13	4.9	T	.0
Vicksburg	247	82	102	29.80	30.06	−.09	53.8	+3.8	78	7	62	30	30	45	27	46	40	68	4.23	−1.1	9	8.3	sw.	34	w.	23	12	6	13	5.1	.0	.0
New Orleans [1]	53	76	84	30.04	30.08	−.05	58.6	+3.0	79	10	67	40	28	50	27	52	48	78	2.74	−2.0	7	5.1	w.	22	nw.	26	15	9	7	4.4	.0	.0
West Gulf States							55.9	+4.3										73	1.74	−1.3										4.2		
Shreveport [2]	249	92	227	29.86	30.06	−.07	54.4	+5.3	83	7	64	28	29	45	32	46	41	74	4.91	+.6	6	11.7	sw.	36	w.	23	14	10	7	4.7	.0	.0
Bentonville	1,303	12	51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fort Smith	463	57	82	29.58	30.07	−.06	46.5	+4.4	74	9	56	19	29	37	31	40	33	65	1.57	−1.2	4	7.7	e.	25	nw.	12	16	6	9	4.1	2.7	.0
Little Rock [2]	357	94	102	29.77	30.06	−.08	47.0	+2.8	76	7	55	22	29	39	31	40	36	78	1.41	−2.7	6	8.0	w.	26	nw.	2	13	7	11	4.9	.1	.0
Austin [2]	605	68	90	29.41	30.08	.....	55.6	+4.6	82	6	68	28	29	43	38	47	41	70	.80	−1.9	4	6.4	nw.	24	nw.	23	17	6	8	3.8	T	.0
Brownsville [2]	57	88	98	30.04	30.06	.....	64.6	+3.4	85	23	74	34	30	55	34	57	54	82	.42	−1.1	3	10.0	s.	33	s.	22	8	15	8	5.1	.0	.0
Corpus Christi [2]	20	11	78	30.03	30.07	−.03	61.8	+3.8	81	12	69	35	29	54	27	54	50	80	2.06	+.6	6	9.6	s.	27	s.	22	13	8	10	5.2	.0	.0
Dallas [2]	512	220	227	29.53	30.06	.....	52.8	.....	80	7	63	24	29	42	31	43	37	69	.65	−1.7	4	11.6	w.	43	sw.	23	21	3	7	3.1	.0	.0
Fort Worth [2]	679	92	110	29.31	30.07	−.05	52.6	+5.1	82	7	65	22	29	41	37	44	37	63	.68	−1.2	3	9.3	w.	38	nw.	23	19	6	6	2.8	.0	.0
Galveston [2]	54	100	114	30.07	30.08	−.04	59.8	+3.4	76	5	66	35	29	54	22	53	50	82	2.31	−1.4	7	9.7	s.	27	n.	25	16	10	5	3.8	.0	.0
Houston [2]	138	157	190	30.01	30.09	.....	59.0	+4.6	83	10	68	29	29	50	27	50	46	78	2.62	−1.6	6	9.6	s.	26	w.	23	11	13	7	4.3	.0	.0
Palestine	510	64	72	29.54	30.08	−.04	54.6	+4.7	81	7	64	23	29	45	30	47	40	64	2.05	−1.6	3	7.4	s.	27	w.	23	18	4	9	4.0	T	.0
Port Arthur	34	59	134	30.04	30.06	.....	57.8	.....	77	5	66	30	29	49	30	...	...	...	2.30	−2.9	7	11.8	s.	38	nc.	25	11	12	8	4.7	.0	.0
San Antonio [2]	693	111	301	29.46	30.08	−.03	58.8	+5.1	85	11	70	32	29	47	34	49	42	66	.89	−.7	4	10.3	s.	37	nw.	23	13	9	9	4.5	.0	.0

See footnotes at end of table.

TABLE 2.—*Climatological data for Weather Bureau stations, December 1939*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*°F.*	*°F.*		*°F.*	*°F.*	*°F.*	*°F.*	*%*	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
							38.9	**+2.3**										**76**	**2.11**	**−1.4**										**6.5**		
Chattanooga [2]	762	71	214	29.31	30.06	−0.10	45.1	+1.8	72	7	54	26	30	36	37	38	33	74	3.39	−1.7	9	8.1	w.	26	w.	2	14	6	11	4.9	0.2	0.0
Knoxville [2]	995	66	84	28.98	30.05	−.11	42.4	+2.1	68	19	51	23	22	34	36	36	32	74	3.18	−1.3	10	6.5	w.	21	w.	13	13	6	12	5.2	T	.0
Memphis [2]	399	78	86	29.74	30.04	−.11	46.6	+3.0	75	7	53	26	31	40	24	40	36	79	2.90	−1.6	8	8.4	sw.	27	nw.	12	11	6	14	5.7	T	T
Nashville [2]	546	168	188	29.38	30.04	−.11	43.6	+2.6	72	7	52	21	31	35	37	37	32	72	2.68	−1.5	8	8.9	w.	25	nw.	13	12	7	12	5.3	T	.0
Lexington	989	6	.....	.....	.....	.....	36.6	+.8	65	7	45	10	25	28	34	.....	.....	.....	2.35	−1.4	11	.....	w.	.....	.....	.....	10	4	17	.....	11.7	.4
Louisville [2]	525	106	120	29.42	30.02	−.12	38.6	+1.0	67	7	46	9	31	31	33	33	28	75	2.43	−1.3	9	9.9	sw.	28	sw.	16	10	5	16	6.4	15.0	3.5
Evansville	431	76	116	29.55	30.03	−.10	38.8	+1.7	68	10	46	5	31	31	27	34	29	71	1.81	−1.7	9	9.6	sw.	25	sw.	12	7	8	16	6.3	11.2	1.8
Indianapolis [2]	823	98	129	29.09	29.98	−.14	36.1	+3.9	60	12	43	1	31	29	28	30	27	80	1.13	−1.8	6	9.1	w.	25	nw.	7	6	10	15	6.7	5.5	3.7
Terre Haute	575	63	149	29.36	30.00	.....	37.0	.....	63	18	45	1	31	29	29	32	27	71	1.49	−1.4	6	10.1	sw.	28	nw.	13	8	8	15	6.3	5.8	2.4
Cincinnati [2]	627	11	51	29.45	30.00	−.13	37.4	+3.0	65	7	44	6	31	30	31	33	29	77	1.41	−1.6	8	9.5	sw.	24	w.	7	9	6	16	6.7	6.2	3.2
Columbus [2]	822	90	110	29.06	29.97	−.15	35.8	+3.4	59	7	42	6	31	30	29	31	28	80	1.20	−1.5	11	11.3	s.	30	sw.	16	5	3	23	7.8	3.1	2.4
Dayton	900	186	213	28.99	29.97	.....	35.8	+3.2	59	7	42	4	31	29	28	32	27	74	1.46	−1.3	10	12.0	sw.	32	nw.	7	6	6	19	7.4	5.4	3.3
Elkins [2]	1,947	65	83	27.82	29.99	−.13	34.8	+2.1	66	19	44	11	31	26	39	30	26	77	2.54	−.9	17	8.1	w.	30	w.	7	5	5	21	7.7	6.9	1.7
Parkersburg	637	77	84	29.29	29.99	−.15	38.2	+3.0	67	19	46	11	31	30	34	34	29	76	2.04	−1.0	12	7.5	sw.	30	w.	7	9	5	17	6.5	7.2	3.0
Pittsburgh [1]	1,273	39	54	28.55	29.94	−.19	34.5	+.3	63	19	41	8	31	28	30	31	27	80	1.66	−1.2	17	13.1	sw.	41	nw.	7	4	5	22	7.8	5.2	2.4
Lower Lake Region							**31.9**	**+2.6**										**80**	**2.17**	**−0.6**										**8.3**		
Buffalo [2]	768	243	280	29.08	29.87	−.19	32.3	+2.5	56	19	38	8	28	27	32	29	26	82	3.00	−.4	15	18.2	w.	54	sw.	7	1	8	22	8.3	8.7	4.3
Canton	448	10	61	29.34	29.83	.....	22.4	−.3	50	2	30	−17	27	15	38	21	19	88	3.47	+.8	20	8.9	sw.	27	w.	7	3	4	24	8.3	12.3	4.5
Ithaca	836	77	100	28.94	29.86	.....	30.2	+1.2	57	7	37	−3	28	24	29	28	24	78	2.76	+.4	14	11.1	nw.	33	nw.	8	2	4	25	8.6	5.2	1.0
Oswego	335	71	85	29.47	29.85	−.21	29.7	+.7	53	7	36	−4	28	24	25	27	22	71	3.17	−.3	17	11.7	nw.	34	nw.	7	2	4	25	8.5	5.3	2.4
Rochester [2]	523	86	102	29.25	29.87	−.19	31.8	+2.5	56	7	37	7	27	26	24	28	26	86	1.97	−.8	15	9.7	w.	34	sw.	7	2	2	27	8.7	2.6	1.0
Syracuse [2]	596	65	79	29.40	29.86	−.21	30.4	+1.4	55	7	37	−2	28	24	31	26	23	80	3.15	+.1	20	8.3	s.	30	nw.	8	2	7	22	8.4	8.8	3.8
Erie	714	57	81	29.11	29.89	−.18	35.3	+3.4	60	19	41	12	31	30	29	32	29	78	2.96	+.1	15	10.5	s.	26	sw.	7	0	8	23	8.6	7.6	1.4
Cleveland [2]	762	267	318	29.04	29.92	−.17	35.9	+4.7	62	18	41	12	31	31	28	31	27	80	1.17	−1.3	16	17.4	sw.	49	nw.	7	0	6	25	8.6	3.9	.8
Sandusky	629	5	67	29.23	29.93	−.16	34.8	+3.6	60	18	40	9	31	29	25	.....	.....	.....	1.40	−.9	11	10.8	sw.	29	nw.	7	3	3	25	8.6	2.3	1.2
Toledo [2]	628	79	87	29.23	29.93	−.15	34.0	+3.6	56	18	39	8	31	29	23	30	26	78	.98	−1.4	12	11.6	w.	32	w.	7	6	6	19	7.4	2.5	.9
Fort Wayne	857	69	84	29.02	29.94	.....	33.0	+3.3	55	9	39	3	31	27	26	29	26	83	.99	−1.6	16	11.1	w.	31	nw.	7	5	8	18	7.2	3.8	2.3
Detroit [1]	626	5	78	29.21	29.90	−.17	33.4	+4.1	54	9	39	8	31	28	21	31	27	79	1.02	−1.3	13	12.5	sw.	34	nw.	7	3	5	23	8.3	1.9	1.0
Upper Lake Region							**30.7**	**+6.2**										**79**	**1.08**	**−0.9**										**7.2**		
Alpena	609	13	89	29.17	29.85	−.17	30.0	+5.2	52	9	35	7	31	25	22	28	24	78	1.25	−.8	13	11.8	nw.	42	nw.	7	2	9	20	7.7	3.5	1.6
Escanaba	612	51	72	29.20	29.88	−.15	29.4	+7.0	56	9	35	3	30	24	20	28	24	80	1.53	−.2	11	11.8	nw.	39	nw.	7	3	10	18	7.6	4.5	1.6
Grand Rapids [2]	707	70	244	29.13	29.90	−.15	34.0	+5.5	55	18	39	11	31	28	18	29	26	81	1.09	−1.5	12	12.3	sw.	36	sw.	19	2	8	21	8.1	7.3	4.5
Lansing	878	5	90	28.94	29.90	.....	31.8	+4.6	53	18	37	6	31	26	21	30	27	86	.89	−1.2	9	10.0	nw.	29	nw.	7	3	8	20	7.7	2.9	2.0
Marquette	734	44	69	29.05	29.86	−.16	30.2	+7.6	57	9	36	4	30	25	22	28	25	83	2.58	−.1	14	9.3	nw.	28	sw.	6	3	10	18	7.5	15.7	6.8
Sault Sainte Marie [1]	724	5	33	29.03	29.84	−.16	25.3	+4.8	47	9	32	0	31	19	29	24	21	82	1.18	−1.2	10	9.0	se.	35	nw.	24	4	8	19	7.5	4.7	2.1
Chicago	673	7	131	29.20	29.95	−.13	35.0	+6.2	57	9	41	3	31	29	19	31	26	70	.90	−1.1	3	11.6	nw.	33	sw.	19	8	6	17	6.6	.5	.0
Green Bay	617	109	141	29.20	29.89	−.15	30.9	+8.6	55	9	36	−1	31	25	21	28	23	73	.68	−1.0	6	11.2	nw.	31	nw.	7	7	7	17	6.8	1.2	.0
Milwaukee [2]	681	97	221	29.16	29.93	−.13	33.8	+7.7	56	9	39	2	31	28	20	29	24	74	.46	−1.3	2	12.9	nw.	38	nw.	7	7	7	17	6.7	.4	.0
Duluth	1,133	8	47	28.64	29.91	−.14	26.5	+10.6	56	6	34	−8	31	19	25	24	20	80	.22	−.9	4	13.7	nw.	48	nw.	12	9	8	14	5.8	1.3	T
North Dakota							**25.8**	**+13.8**										**76**	**0.42**	**−0.2**										**6.3**		
Moorhead, Minn	940	50	58	28.98	30.00	−.08	25.2	+13.7	65	6	34	−8	30	16	41	21	17	78	.39	−.3	4	8.3	s.	29	nw.	1	6	9	16	7.0	2.2	1.0
Bismarck	1,677	8	57	28.20	30.03	−.05	27.7	+13.0	66	6	38	−9	29	18	41	23	17	71	.26	−.3	6	7.4	w.	38	nw.	1	9	9	13	6.1	3.9	3.0
Devils Lake	1,478	11	44	28.35	29.98	−.08	24.5	+15.0	64	6	33	−13	30	16	32	22	18	84	.35	−.2	6	8.5	w.	35	nw.	16	5	7	19	7.0	2.0	1.4
Lemmon, S. Dak	2,602	4	38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Grand Forks	832	11	71	.....	.....	.....	23.4	+12.8	58	6	32	−10	30	15	36	21	19	.....	.40	−.2	7	.....	nw.	.....	.....	.....	.....	.....	.....	.....	1.4	.7
Williston	1,878	42	50	27.96	30.00	−.06	28.4	+14.6	63	6	38	−13	31	19	35	24	19	72	.69	+.1	9	7.2	sw.	34	nw.	11	13	7	11	5.2	3.8	3.2
Upper Mississippi Valley							**34.0**	**+7.0**										**73**	**0.68**	**−1.0**										**5.8**		
Minneapolis-St. Paul, Minn. [1]	838	32	61	29.04	29.97	−.11	27.6	+8.0	63	6	37	−4	31	19	36	24	20	75	.97	.0	5	10.3	nw.	37	nw.	7	9	6	16	6.3	4.8	2.6
Springfield, Minn	1,025	4	42	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
La Crosse [2]	714	11	48	29.21	29.96	−.12	30.5	+8.2	55	6	38	−2	31	22	28	23	22	78	.48	−1.0	2	6.2	s.	22	nw.	7	8	8	15	6.2	.5	T
Madison	974	70	78	28.98	29.94	−.14	31.8	+9.0	54	9	38	−1	31	25	21	27	23	76	.28	−1.4	2	9.6	nw.	30	nw.	7	8	9	14	6.4	T	.0
Charles City	1,015	10	51	28.87	30.00	−.10	29.2	+8.8	61	16	39	−1	31	20	35	25	21	75	.40	−.9	3	6.4	nw.	19	nw.	7	9	12	10	5.7	1.0	T
Davenport	606	66	161	29.31	29.99	−.11	34.8	+7.7	64	18	43	4	31	27	27	30	24	68	.09	−1.4	2	10.5	nw.	32	nw.	7	9	11	11	5.5	T	T
Des Moines [2]	860	5	99	28.94	30.00	−.11	34.0	+8.0	69	6	44	0	31	24	40	28	22	69	.44	−.8	5	9.3	nw.	33	nw.	12	11	8	12	5.5	4.2	3.2
Dubuque	699	60	79	29.20	29.97	−.13	33.2	+8.5	58	16	41	2	31	25	30	29	23	69	.24	−1.2	3	6.7	nw.	22	nw.	7	10	8	13	5.8	T	.0
Keokuk	614	64	78	29.34	30.01	−.11	36.1	+6.5	68	18	45	−2	31	28	30	31	24	67	.34	−1.1	3	7.9	nw.	24	nw.	12	10	9	12	5.5	5.9	3.8
Cairo	358	87	93	29.65	30.04	−.11	41.7	+3.9	71	7	50	11	31	34	28	36	31	71	1.75	−1.6	6	9.0	sw.	25	ne.	23	9	6	16	6.2	1.9	.6
Peoria [2]	609	11	45	29.26	29.99	−.12	33.9	+5.8	62	18	43	−1	31	25	28	28	25	80	.61	−1.2	5	6.5	s.	22	w.	19	14	7	10	4.8	8.0	3.8
Springfield, Ill. [2]	636	8	191	29.32	30.00	−.12	36.2	+4.5	63	18	44	0	31	29	26	29	26	84	1.09	−1.1	6	11.9	nw.	29	nw.	13	7	11	13	6.3	6.9	3.7
St. Louis [2]	568	179	303	29.40	30.02	−.11	39.4	+4.5	72	9	47	4	31	32	31	34	28	66	1.43	−.8	7	11.9	nw.	26	nw.	19	10	9	12	5.7	10.5	4.1
Missouri Valley							**36.3**	**+7.9**										**69**	**0.77**	**−0.4**										**5.4**		
Columbia, Mo. [2]	784	6	66	29.17	30.03	−.09	38.2	+5.0	71	18	47	2	31	29	35	32	27	73	1.16	−.7	8	7.5	w.	25	nw.	13	9	10	12	6.0	7.0	3.8
Kansas City [1]	750	38	76	29.20	30.03	−.09	39.4	+6.9	74	6	48	7	29	30	41	33	26	65	.68	−.6	6	9.7	sw.	34	nw.	1	9	10	12	5.6	4.1	1.4
St. Joseph [2]	967	11	49	29.14	30.03	.....	38.0	+8.4	72	6	47	6	29	29	37	31	26	75	.72	−.6	6	8.4	nw.	31	nw.	12	13	7	11	5.0	3.5	2.2
Springfield, Mo. [2]	1,324	5	78	28.57	30.04	−.09	40.8	+4.6	72	6	49	8	29	32	35	33	28	73	1.66	−.6	4	9.2	w.	26	nw.	2	12	9	10	5.2	7.0	4.5
Topeka	987	65	87	28.96	30.04	.....	39.7	+7.7	77	6	50	4	29	30	38	33	25	61	.74	−.2	5	8.3	w.	25	nw.	12	12	13	6	4.9	4.5	2.7
Lincoln [2]	1,189	11	81	28.74	30.05	−.07	36.0	+8.4	75	6	46	−5	29	26	38	27	21	67	.94	+.1	6	8.6	nw.	36	nw.	2	10	13	8	5.1	8.0	5.0
Omaha [1]	982	31	44	28.96	30.04	−.07	34.2	+7.8	72	6	44	1	29	24	40	29	23	70	.62	−.3	6	9.2	nw.	37	nw.	12	7	11	13	6.0	8.4	5.8
Valentine	2,598	47	54	27.27	30.06	−.04	34.2	+9.6	76	11	46	−8	28	22	39	28	20	64	.77	+.2	6	8.8	w.	32	nw.	1	9	17	5	4.9	9.1	7.0
Sioux City	1,138	64	106	28.78	30.03	−.09	32.4	+9.3	71	6	43	−1	31	22	46	28	22	68	.28	−.6	5	8.9	nw.	40	nw.	1	8	10	13	6.0	2.7	1.7
Huron [1]	1,289	27	41	28.62	30.04	−.06	29.8	+11.1	71	6	41	−10	29	18	46	24	18	71	.15	−.4	5	11.4	nw.	50	nw.	12	10	12	9	5.4	1.8	.5

See footnotes at end of table.

TABLE 2.—*Climatological data for Weather Bureau stations, December 1939*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0–10	In.	In.
Northern Slope							33.0	+9.3										64	0.64	−0.1										6.5		
Billings	3,570	17	31	26.31	30.06	.....	37.6	.....	69	5	47	1	26	28	35	31	20	54	0.12	.....	4	13.1	sw.	43	nw.	1	4	12	15	7.2	2.1	T
Havre	2,507	11	67	27.32	30.02	−.03	32.2	+11.8	71	5	43	−17	27	22	42	26	19	62	.99	+.4	6	10.4	sw.	38	sw.	11	9	9	13	5.9	8.1	3.0
Helena	4,124	85	111	25.81	30.10	−.03	33.6	+9.4	63	10	42	1	28	26	27	28	21	62	.34	−.4	8	6.7	sw.	31	w.	11	3	3	25	8.3	2.7	.1
Missoula [2]	3,263	80	91	.....	.....	.....	33.4	+8.9	54	6	39	6	28	28	25	30	28	87	1.94	+.8	14	5.8	se.	32	w.	10	2	5	24	8.5	5.1	3.5
Kalispell	2,973	48	56	26.98	30.11	+.04	31.4	+6.5	52	6	38	0	27	25	22	30	27	83	.94	−.5	18	4.4	nw.	23	sw.	11	2	7	22	8.0	5.2	1.7
Miles City [2]	2,371	48	55	27.22	30.06	−.04	31.9	+10.9	71	5	44	−13	28	20	40	26	19	65	.38	−.2	7	6.5	s.	35	nw.	1	4	14	13	6.6	2.9	2.0
Rapid City [2]	3,259	50	58	26.65	30.06	−.03	36.6	+9.7	79	5	48	3	28	25	43	27	17	57	.31	−.1	5	8.1	nw.	35	n.	18	15	7	9	4.6	2.7	1.3
Cheyenne [1]	6,144	5	39	23.94	30.07	−.02	35.0	+6.5	69	5	48	−7	28	22	42	27	15	47	.26	−.3	4	13.7	nw.	47	nw.	16	7	16	8	5.7	3.6	T
Lander	5,352	60	68	24.67	30.12	−.03	31.4	+11.0	64	10	45	−6	28	18	39	24	16	58	.07	−.6	4	4.9	sw.	31	w.	17	9	18	4	4.9	.7	T
Sheridan	3,790	10	47	26.10	30.09	.....	33.8	.....	77	5	48	−6	28	19	51	26	17	56	.24	−.4	9	5.2	nw.	29	nw.	1	8	18	5	5.5	2.0	T
Yellowstone Park	6,235	12	46	23.92	30.23	+.07	29.0	+9.6	58	5	37	−7	28	21	30	25	19	69	.94	+.2	16	8.5	s.	31	w.	2	3	9	19	7.3	13.9	6.1
North Platte [2]	2,821	11	51	27.11	30.10	.00	35.0	+8.3	76	6	48	−7	28	22	46	25	18	66	.64	+.1	5	7.0	nw.	30	nw.	1	9	11	11	5.2	7.9	3.5
Middle Slope							40.2	+6.7										55	0.66	−0.2										4.2		
Denver [2]	5,292	106	113	24.71	30.07	−.01	40.8	+8.5	79	5	53	6	27	29	37	28	16	46	0.26	−.5	4	8.3	s.	28	ne.	31	11	13	7	4.9	4.1	0.0
Pueblo [2]	4,690	79	86	25.19	30.11	+.03	36.5	+5.0	78	5	53	−10	27	20	52	25	14	53	.41	−.1	4	5.2	nw.	26	w.	8	15	11	5	4.0	5.3	T
Concordia	1,302	50	58	28.54	30.06	−.05	37.2	+6.5	76	6	48	−5	29	26	36	30	21	60	.54	−.1	5	7.3	w.	26	nw.	1	14	10	7	4.3	4.8	3.0
Dodge City	2,509	10	86	27.41	30.07	−.03	39.4	+6.8	81	6	52	−1	28	27	48	30	19	52	.89	+.3	3	11.1	nw.	36	n.	12	13	12	6	4.3	4.6	1.4
Wichita [2]	1,358	85	93	28.53	30.04	−.07	41.1	+6.5	75	11	52	5	29	30	35	32	23	59	.95	.0	4	8.9	nw.	24	nw.	12	20	3	8	3.5	5.0	1.0
Oklahoma City [2]	1,214	10	47	28.65	30.06	−.05	46.3	+7.0	77	6	56	17	28	36	35	36	28	59	.93	−.6	4	9.1	nw.	30	n.	12	13	11	7	4.3	3.0	T
Chadron, Nebr	3,439	4	58	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Southern Slope							48.6	+4.5										60	0.98	+0.1										3.5		
Abilene [2]	1,738	10	56	28.22	30.07	−.04	49.9	+3.9	83	11	62	19	29	38	40	39	32	63	.79	−.6	4	8.3	s.	28	w.	23	18	6	7	3.6	5.5	.0
Amarillo [2]	3,676	10	49	26.36	30.08	−.01	44.0	+7.0	83	6	57	6	29	31	41	30	21	60	.98	+.2	5	8.3	w.	21	ne.	12	19	7	5	3.1	10.4	1.9
Del Rio	960	63	71	29.06	30.06	−.04	55.3	+3.1	83	10	66	29	29	44	35	47	39	62	1.47	+.8	3	6.2	nw.	25	e.	25	14	8	9	4.7	.0	.0
Roswell	3,566	75	85	26.42	30.08	+.01	45.1	+3.9	81	10	61	17	29	30	48	36	25	53	.70	.0	4	6.2	s.	29	ne.	12	21	8	2	2.5	2.0	.0
Southern Plateau							46.9	+6.2										55	0.14	−0.7										2.5		
El Paso [2]	3,778	82	101	26.11	30.08	+.05	49.4	+4.5	75	9	62	24	29	37	36	38	29	55	.19	−.3	2	6.9	w.	31	nw.	22	23	5	3	2.1	T	.0
Albuquerque [1]	5,314	5	34	24.80	30.10	.....	40.0	+5.5	65	10	53	14	27	27	34	32	24	58	.10	−.4	2	6.7	ne.	30	e.	25	21	6	4	3.0	.3	T
Santa Fe	7,013	38	53	23.27	30.13	+.07	36.8	+6.1	63	5	48	3	27	26	30	28	19	54	.57	−.2	5	6.1	n.	18	n.	29	17	11	3	3.0	4.8	1.0
Flagstaff	6,907	10	59	23.39	30.06	0.00	37.0	+8.6	65	10	54	7	26	20	43	29	23	64	.03	−2.0	1	6.8	nw.	24	nw.	27	19	9	3	.....	T	.0
Phoenix [2]	1,107	39	51	28.90	30.02	−.02	57.6	+5.6	84	8	72	31	27	43	37	45	36	55	T	−1.0	0	4.4	e.	17	w.	22	18	7	6	3.4	.0	.0
Yuma	141	9	54	29.89	30.04	−.01	61.0	+5.8	82	8	74	36	27	48	30	49	36	43	.00	−.5	0	5.5	w.	23	nw.	25	28	3	0	.8	.0	.0
Independence	3,957	5	26	26.06	30.13	+.01	46.8	+7.5	73	4	61	25	26	32	37	36	20	...	.09	−.7	1	.....	n.	17	s.	10	...	...	...	...	.0	.0
Middle Plateau							37.7	+7.5										65	0.43	−0.6										5.6		
Reno [2]	4,527	61	76	25.66	25.66	30.14	41.2	+7.9	67	16	53	14	25	30	40	34	27	65	.34	−.6	5	5.2	w.	30	s.	10	13	9	9	.....	.3	.0
Tonopah	6,090	12	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Winnemucca	4,344	18	56	25.70	30.16	−.02	37.2	+7.2	70	10	50	2	25	24	43	33	27	70	.94	−.1	9	6.6	ne.	30	s.	10	7	8	16	6.5	2.1	.0
Modena	5,473	10	43	24.70	30.13	+.01	36.1	+8.0	63	15	51	7	27	21	41	30	22	61	.08	−.8	2	8.0	w.	25	nw.	18	9	10	12	5.6	1.1	.0
Salt Lake City [1]	4,227	32	46	25.84	30.19	+.04	39.0	+7.1	68	10	48	9	28	30	27	31	26	71	.66	−.8	7	5.6	nw.	25	nw.	11	8	10	13	5.9	5.6	.0
Grand Junction	4,602	60	68	25.50	30.16	+.08	35.0	+7.5	59	11	48	5	28	22	35	29	20	57	.13	−.5	2	4.4	se.	23	nw.	11	15	7	9	4.3	1.4	.0
Northern Plateau							38.1	+7.5										78	1.77	0.0										8.1		
Baker	3,471	36	54	26.61	30.15	−.01	36.0	+8.7	60	10	44	5	25	29	27	32	28	79	.85	−.8	16	5.8	se.	25	sw.	16	3	9	19	7.8	2.8	T
Boise	2,739	79	87	27.24	30.17	−.03	40.2	+8.1	70	10	48	16	26	33	27	35	32	79	1.39	−.2	17	5.1	se.	25	se.	10	3	7	21	7.9	1.5	.0
Pocatello [1]	4,478	5	31	25.57	30.19	−.01	34.2	+6.5	63	10	45	−7	28	23	40	30	24	71	.54	.....	7	8.5	sw.	45	w.	11	2	9	20	7.8	1.3	.0
Spokane [2]	1,929	101	110	27.97	30.09	+.01	37.0	+6.5	60	10	42	20	24	32	26	35	32	82	2.83	+.6	17	6.2	s.	20	s.	15	4	4	23	8.3	3.9	2.9
Walla Walla	991	57	65	29.00	30.09	−.03	42.8	+7.3	68	10	49	25	26	36	30	39	35	77	2.35	+.3	18	5.5	s.	24	w.	10	1	5	25	9.0	1.2	.0
Yakima	1,076	58	67	28.92	30.09	.....	38.4	+7.7	58	15	45	18	25	31	31	36	32	77	1.44	+.1	13	4.1	nw.	29	se.	30	4	3	24	8.0	3.1	1.2
North Pacific Coast Region							46.7	+5.1										86	9.81	+2.6										8.8		
North Head	211	8	56	29.74	29.96	−.07	48.6	+4.5	61	4	52	34	24	45	13	47	45	89	12.75	+3.3	26	19.9	se.	70	s.	14	2	6	23	8.0	.0	.0
Seattle [2]	125	90	321	29.96	30.00	−.01	47.5	+5.8	65	4	52	28	24	42	15	44	42	86	10.41	+4.8	20	10.2	s.	42	sw.	8	2	5	24	8.6	.0	.0
Tacoma	203	172	201	29.79	30.00	−.01	45.9	+5.3	65	4	51	26	25	41	15	.....	.....	...	8.31	+1.6	21	7.9	s.	34	s.	15	6	6	25	9.1	.0	.0
Tatoosh Island	86	9	55	29.80	29.89	−.07	48.3	+4.4	57	4	51	40	24	45	13	46	44	84	14.81	+1.4	26	22.0	e.	61	s.	8	2	4	25	8.5	.0	.0
Medford [1]	1,329	29	58	28.67	30.11	.....	42.5	+5.1	62	31	49	25	5	36	30	41	39	88	6.71	+3.6	18	.....	nw.	.....	.....	.....	0	4	27	9.1	.6	.0
Portland, Oreg	154	68	106	29.98	30.03	−.04	46.4	+5.2	62	4	51	28	25	42	23	44	42	88	8.37	+1.6	23	6.0	se.	22	s.	14	1	4	26	9.1	.0	.0
Roseburg	510	48	76	29.50	30.05	−.06	47.5	+5.7	64	8	54	29	25	41	20	45	42	83	7.34	+2.0	19	3.5	s.	22	se.	7	1	5	25	9.0	.0	.0
Middle Pacific Coast Region							51.9	+4.0										75	5.85	+1.1										7.6		
Eureka	60	72	88	30.01	30.08	−.04	52.6	+4.4	68	1	59	36	25	46	19	49	46	81	12.13	+5.8	16	7.5	se.	35	s.	9	3	5	23	8.3	.0	.0
Redding [1]	722	20	34	29.34	30.12	.....	49.9	+3.8	74	2	57	36	26	43	34	45	39	69	9.07	+3.5	14	6.9	nw.	42	se.	10	7	3	21	7.4	.0	.0
Sacramento [2]	66	92	115	30.10	30.13	−.02	49.8	+3.6	68	2	58	33	25	41	28	46	42	76	1.15	−1.9	7	6.4	n.	32	se.	10	5	8	18	7.1	.0	.0
San Francisco	155	112	132	29.94	30.11	−.01	55.3	+4.0	69	3	60	44	25	50	18	51	47	75	1.05	−2.9	10	6.0	n.	34	s.	10	6	3	22	7.5	.0	.0
South Pacific Coast Region							58.4	+5.4										68	0.32	−1.6										4.5		
Fresno [1]	327	97	105	29.82	30.14	+.01	49.9	+3.7	74	10	61	30	25	38	34	46	41	74	.11	−1.3	3	4.3	se.	23	nw.	19	3	10	18	7.3	.0	.0
Los Angeles	338	189	191	29.69	30.05	−.02	64.2	+7.6	88	4	74	45	24	54	31	53	44	54	.38	−2.2	4	5.1	ne.	18	se.	23	20	7	4	2.9	.0	.0
San Diego [2]	87	62	70	30.01	30.04	−.03	61.0	+5.0	80	3	70	45	26	52	28	54	50	75	.48	−1.4	2	5.0	nw.	24	s.	23	17	9	5	3.3	.0	.0
West Indies																																
San Juan, P. R	82	9	54	29.91	30.00	.....	76.9	+.6	86	31	82	70	3	72	14	.....	.....	.....	4.72	−.8	15	9.0	e.	29	e.	17	2	25	4	5.7	.0	.0
Panama Canal																																
Balboa Heights	118	6	92	.....	[3]29.83	+.02	80.6	+.6	90	2	87	73	12	74	16	.....	.....	[3]83	6.23	+1.6	13	6.2	nw.	21	n.	24	0	21	10	6.8	.0	.0
Cristobal	30	6	97	.....	[3]29.85	+.01	80.6	+.7	88	2	85	72	6	76	11	76	75	[3]85	17.08	+5.5	26	9.4	n.	35	w.	6	0	4	27	8.6	0	.0

See footnotes at end of table.

TABLE 2.—*Climatological data for Weather Bureau stations, December 1939*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Alaska	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	U	*In.*	*In.*		*Miles*								0–10	*In.*	*In.*
Fairbanks	454	11	87	[4] 28.92	[4] 29.47	------	0.0	+7.0	42	22	8	−28	2	−8	38	0	−4	80	0.05	−.6	2	4.1	n.	24	ne.	21	8	8	15	6.7	1.5	10.5
Juneau	80	96	116	------	[4] 29.52	------	39.9	+8.7	50	25	44	32	1	36	13	----	----	----	9.70	+2.0	27	9.7	se.	35	se.	3	0	0	31	9.9	2.4	.0
Nome	22	5	57	[4] 29.45	[4] 29.47	------	2.0	−4.5	31	22	9	−18	2	−5	31	2	−2	77	.35	−.7	11	5.6	n.	30	se.	22	5	8	18	7.4	3.5	2.0
Hawaiian Islands																															
Honolulu	38	86	100	29.96	30.00	------	73.1	+.7	81	16	78	64	8	69	14	67	64	76	.55	−3.4	12	8.4	e.	30	sw.	27	8	18	5	5.4	.0	.0
LATE REPORTS FOR NOVEMBER 1939																															
Greenville, Maine	1,069	4	41	28.89	30.09	------	29.2	------	46	30	37	7	20	22	26	26	20	---	2.69	------	7	------	nw.	30	nw.	17	9	7	14	----	.5	.0
Lemmon, S. Dak	2,602	4	38	------	------	------	37.5	------	66	16	51	9	2	24	39	29	21	---	T	------	0	11.4	s.	33	n.	23	---	---	---	---	T	.0
Springfield, Minn	1,025	4	42	------	------	------	38.4	------	70	16	51	15	27	26	44	29	21	---	.02	------	2	5.8	s.	----	------	---	---	---	---	---	----	.0

[1] Data are airport records.
[2] Barometric and hygrometric data from airport, other data city office records.
[3] Observations taken hourly.
[4] Pressure not reduced to mean of 24 hours.

NOTE.—Except as indicated by notes 1 and 2, data in table 2 are city office records.

TABLE 3.—*Data furnished by Canadian Meteorological Service, December 1939*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Mean maximum	Temperature of the air: Mean minimum	Temperature of the air: Highest	Temperature of the air: Lowest	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Total snowfall
	Feet	*In.*	*In.*	*In.*	°F.	°F.	°F.	°F.	°F.	°F.	*In.*	*In.*	*In.*
Cape Race, Newfoundland	90				32.7	+2.5	37.2	28.2	47	16	4.37	−0.69	8.0
Sydney, Cape Breton Island	48	29.51	29.64	−0.26	31.8	+2.8	36.9	26.8	55	15	4.38	−.97	13.3
Halifax, Nova Scotia	88	29.43	29.70	−.25	29.8	+1.5	35.2	24.4	52	9	4.78	−.62	5.2
Yarmouth, Nova Scotia	65	29.61	29.72	−.24	32.3	+1.3	37.6	27.0	56	11	4.63	−1.12	22.2
Charlottetown, Prince Edward Island	38	29.59	29.67	−.25	27.2	+2.0	31.9	22.4	55	6	3.99	−.62	23.8
Chatham, New Brunswick	28	29.55	29.66	−.29	22.6	+3.6	29.2	15.9	52	−3	2.12	−1.07	8.9
Father Point, Quebec	20	29.68	29.71	−.25	22.1	+5.6	26.7	17.5	48	2	3.01	+.30	12.1
Quebec, Quebec	296												
Doucet, Quebec	1,236												
Montreal, Quebec	187	29.60	29.82	−.21	22.0	+2.4	26.9	17.1	48	−4	3.57	−.17	14.6
Ottawa, Ontario	236	29.44	29.82	−.23	19.5	+1.8	25.8	13.2	46	−10	3.66	+.82	25.4
Kingston, Ontario	285	29.53	29.85	−.20	26.8	+2.4	33.4	20.3	48	−2	3.72	+.86	10.1
Toronto, Ontario	379	29.44	29.87	−.19	31.4	+3.9	36.2	26.6	49	5	1.24	−1.34	2.9
Cochrane, Ontario	930				14.2	+6.2	20.8	7.6	37	−18	2.74	+1.17	25.0
White River, Ontario	1,244	28.48	29.88	−.13	17.1	+8.5	25.0	9.3	39	−23	2.16	+.36	19.0
London, Ontario	808	29.00	29.90		30.5	+3.7	35.7	25.4	50	4	1.83	−1.71	5.2
Southampton, Ontario	656	29.12	29.85	−.17	29.4	+2.9	35.4	23.5	50	4	2.24	−1.64	12.8
Parry Sound, Ontario	688	29.14	29.85	−.17	25.1	+4.3	31.3	18.9	45	−5	1.22	−3.23	1.8
Port Arthur, Ontario	644	29.18	29.91	−.13	22.4	+8.8	29.8	15.1	50	−9	.49	−.40	2.2
Winnipeg, Manitoba	760	29.08	29.96	−.14	20.9	+14.9	28.1	13.7	53	−14	.30	−.61	1.4
Minnedosa, Manitoba	1,690	28.10	29.98	−.10	22.2	+14.2	29.5	14.8	54	−13	.14	−.45	1.3
Le Pas, Manitoba	860	28.95	29.96	−.09	14.3	+14.1	21.7	7.0	48	−27	1.00	+.46	8.0
Qu'Appelle, Saskatchewan	2,115	27.62	29.97	−.11	22.7	+13.3	30.4	15.1	58	−22	1.18	+.45	10.7
Moose Jaw, Saskatchewan	1,759				26.6	+15.5	34.9	18.3	67	−11	.65	+.06	6.5
Swift Current, Saskatchewan	2,392	27.10	30.01	−.07	27.9	+10.9	37.6	18.2	68	−11	.65	+.01	4.9
Medicine Hat, Alberta	2,365	27.42	29.98	−.08	28.8	+9.4	40.3	17.2	67	−20	1.03	+.35	7.8
Calgary, Alberta	3,540												
Banff, Alberta	4,521												
Prince Albert, Saskatchewan	1,450	28.35	29.96	−.12	17.4	+12.2	24.4	10.5	50	−15	1.75	+1.03	17.3
Battleford, Saskatchewan	1,592	28.12	29.93	−.14	18.0	+11.8	26.0	10.0	54	−20	1.20	+.79	10.5
Edmonton, Alberta	2,150	27.47	29.88		24.9	+10.9	32.8	17.0	61	−8	.45	−.31	3.0
Kamloops, British Columbia	1,262	28.62	29.99	−.12	39.4	+12.2	44.5	34.3	60	21	.72	−.34	1.6
Victoria, British Columbia	230	29.69	29.94	−.10	45.8	+4.8	49.3	42.3	55	42	5.47	+.09	.6
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20	29.81	29.83	−.12	46.8	+4.7	50.9	42.6	54	31	26.37	+10.67	.0
Prince Rupert, British Columbia	170												
St. George's, Bermuda	151												
LATE REPORTS FOR NOVEMBER 1939													
Battleford, Saskatchewan	1,592	28.22	30.00	−0.04	28.2	+8.0	38.2	18.2	56	−8	.45	0.00	1.4
St. George's, Bermuda	158	----------	30.04	−.01	69.3	+1.2	73.6	65.1	83	55	8.02	+2.93	.0

TABLE 4.—*Severe local storms, December 1939*

[Compiled by Mary O. Souder from reports submitted by Weather Bureau officials]

The table herewith contains such data as has been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the Untited States Meteorological Yearbook]

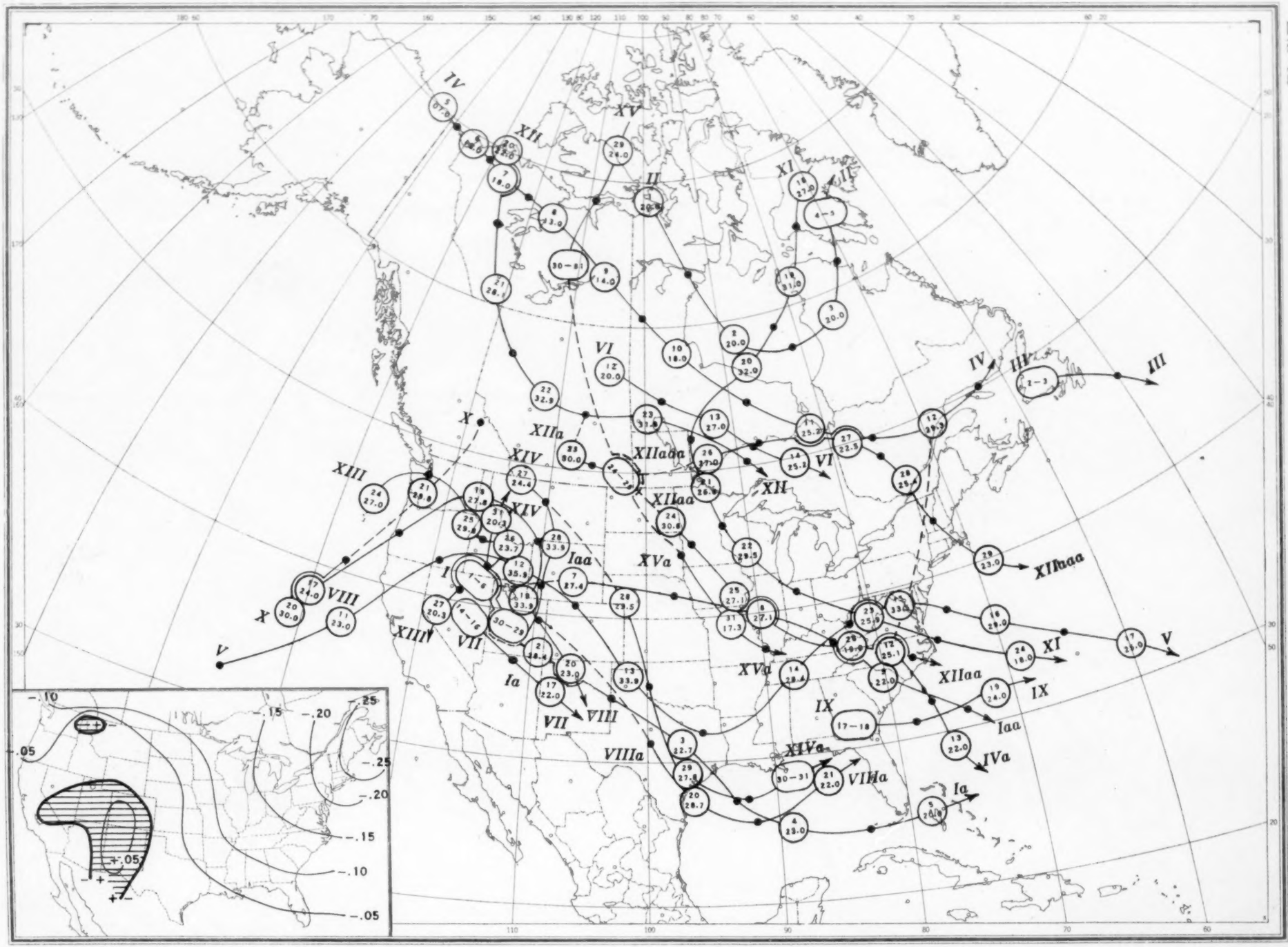
Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Rochester, N. Y., and vicinity.	6					Wind	Falling trees and limbs caused much damage to telephone and power lines; minor property damage.
New York, N. Y., and vicinity.[1]	8					do	Wind velocity of 56 miles recorded at 3:15 a. m., remaining high along the coast all day. Barges torn from their moorings. A ferry plying between Nyack and Tarrytown blown onto a mud bank remaining for more than 9 hours. Small buildings lifted from their foundations. A cross blown from a Brooklyn church steeple and a 15-ton trailer truck blown over in Newark, N. J.
California, northern portion	10					Straight-line wind	Damage to small buildings and power lines in portions of Siskiyou County.
Port Angeles, Wash.	10					Wind	All communication lines disrupted.
New Orleans, La.	26	5 a. m.			$3,400	do	A house and contents destroyed; other property damaged; 3 persons injured.
Indiana, Ohio River to north of Monticello and Bluffton.[1]	27					Snow	Motor traffic throughout the northern and central parts of the State interrupted as sleet covered windshields. In Indianapolis traffic slowed to a snail's pace and streetcars and buses were jammed as motorists abandoned their cars in garages and took to the street railways All commercial air lines operating into Indianapolis ordered their planes grounded.
Washington, D. C., and vicinity.[1]	27			3		Snow and wind	3-inch, 8-hour snowfall and low temperature caused injury to 12 persons. A biting northwest wind handicaped snow-removal squads as they sought to open streets and highways. Streets ice-covered at night as dropping temperatures froze the slush. Rock Creek Park and roads in nearby Virginia and Maryland trapped motorists who attempted to drive to work in the morning rush hours. Property damage not estimated.

[1] From press reports.

Chart I. Departure (°F.) of the Mean Temperature from the Normal and Wind Roses for Selected Stations, December 1939

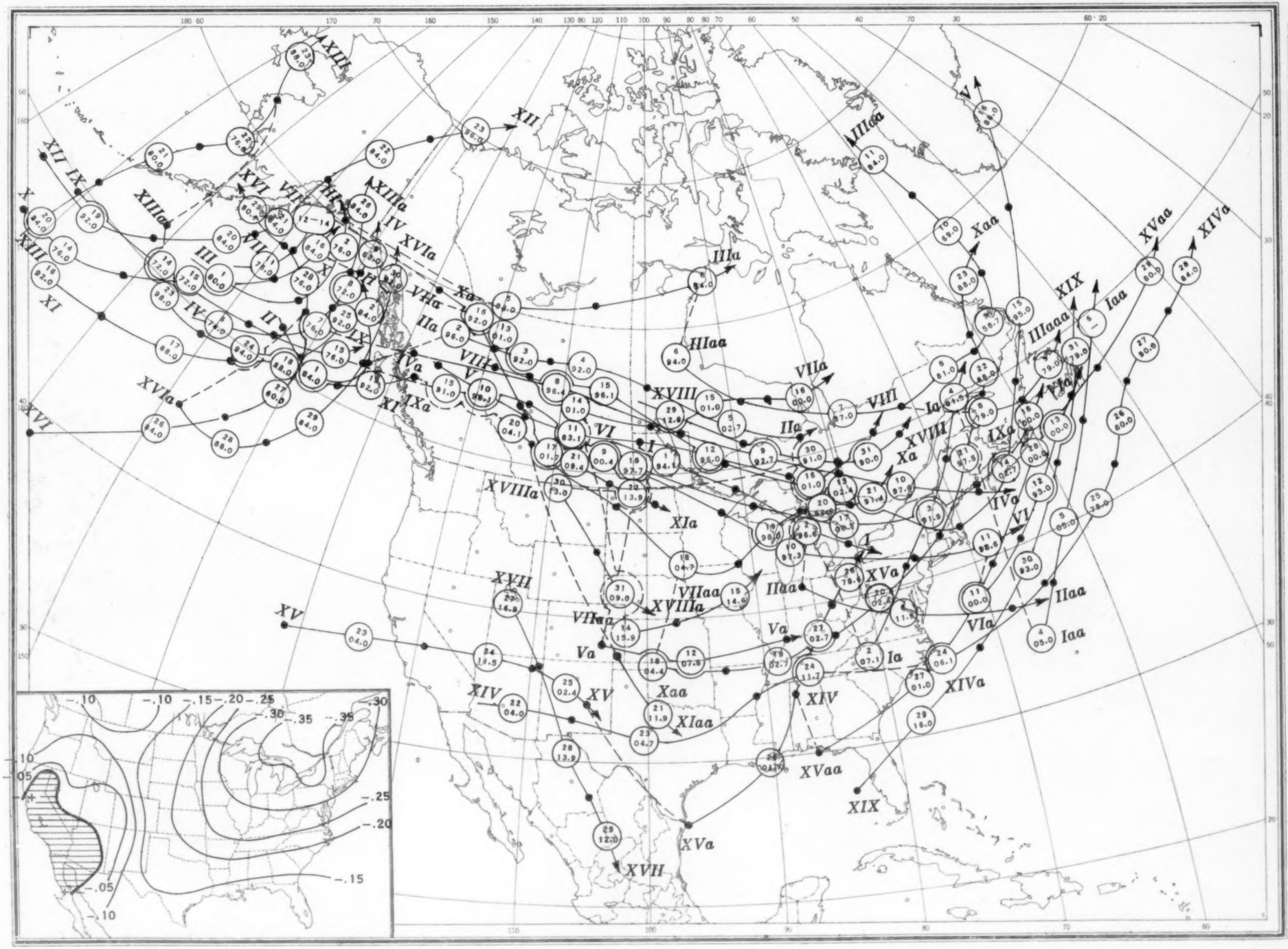
Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, December 1939

Chart II. Tracks of Centers of Anticyclones, December 1939. (Inset) Departure of Monthly Mean Pressure from Normal



Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, December 1939. (Inset) **Change in Mean Pressure from Preceding Month**



Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, December 1939

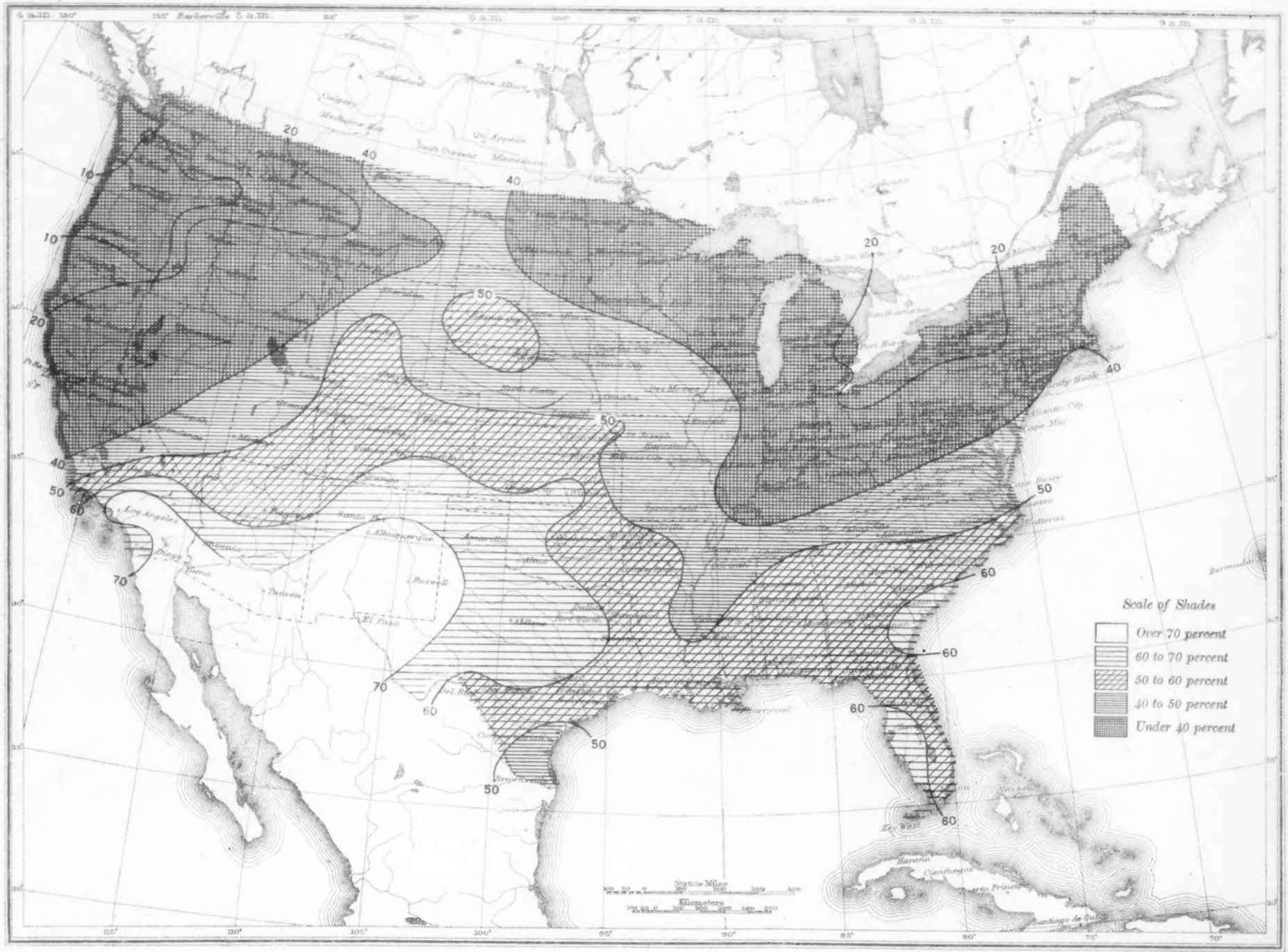


Chart V. Total Precipitation, Inches, December 1939. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, December 1939. (Inset) Departure of Precipitation from Normal

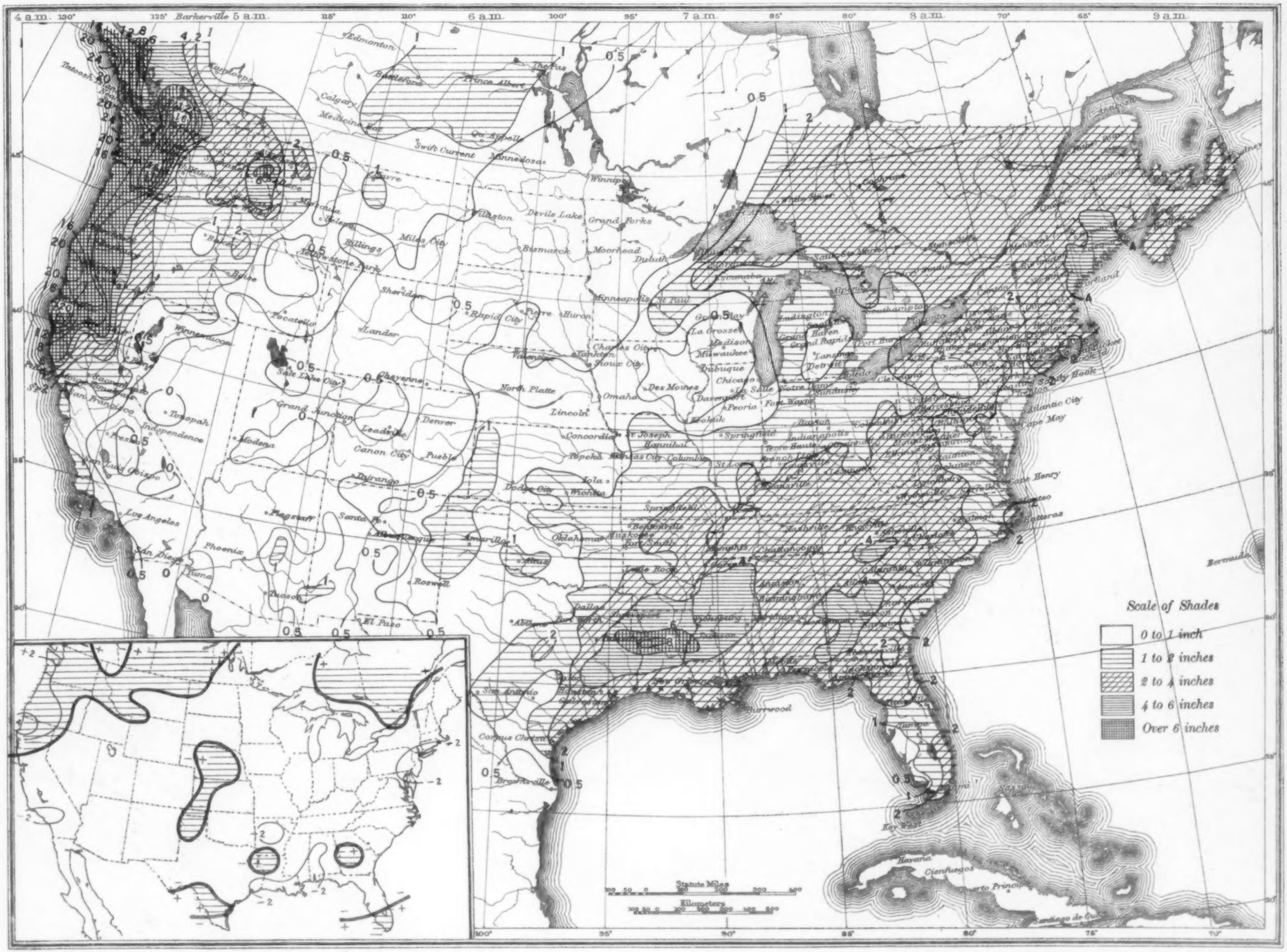


Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, December 1939

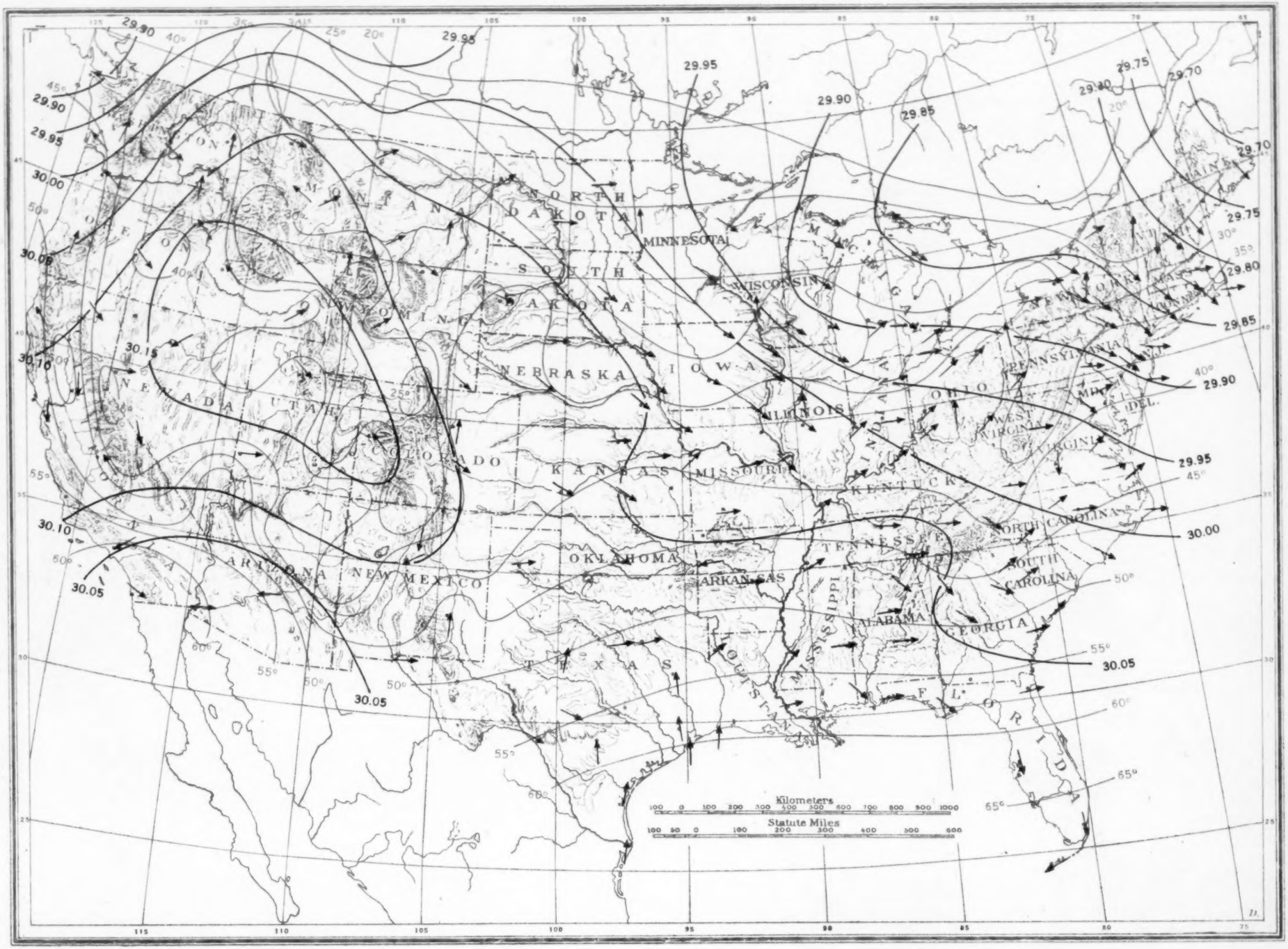


Chart VII. Total Snowfall, Inches, December 1939. (Inset) **Depth of Snow on the Ground at 7:30 p.m., Monday, January 1, 1940**

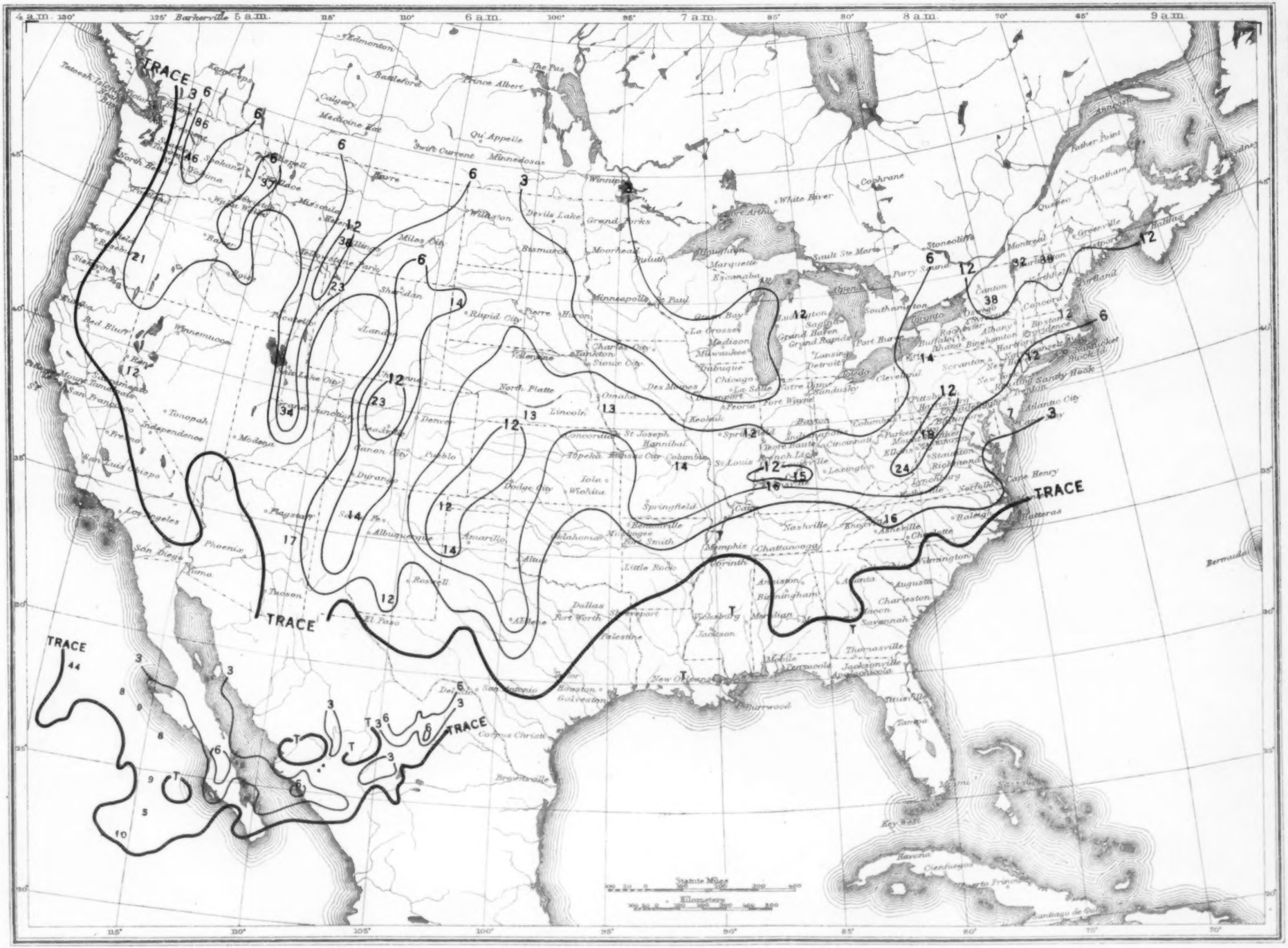


Chart VIII. Isobars (mb) for 1,524 Meters (5,000 ft.) and Isotherms (°C.) and Resultant Winds for 1,500 Meters (m. s. l.) December 1939

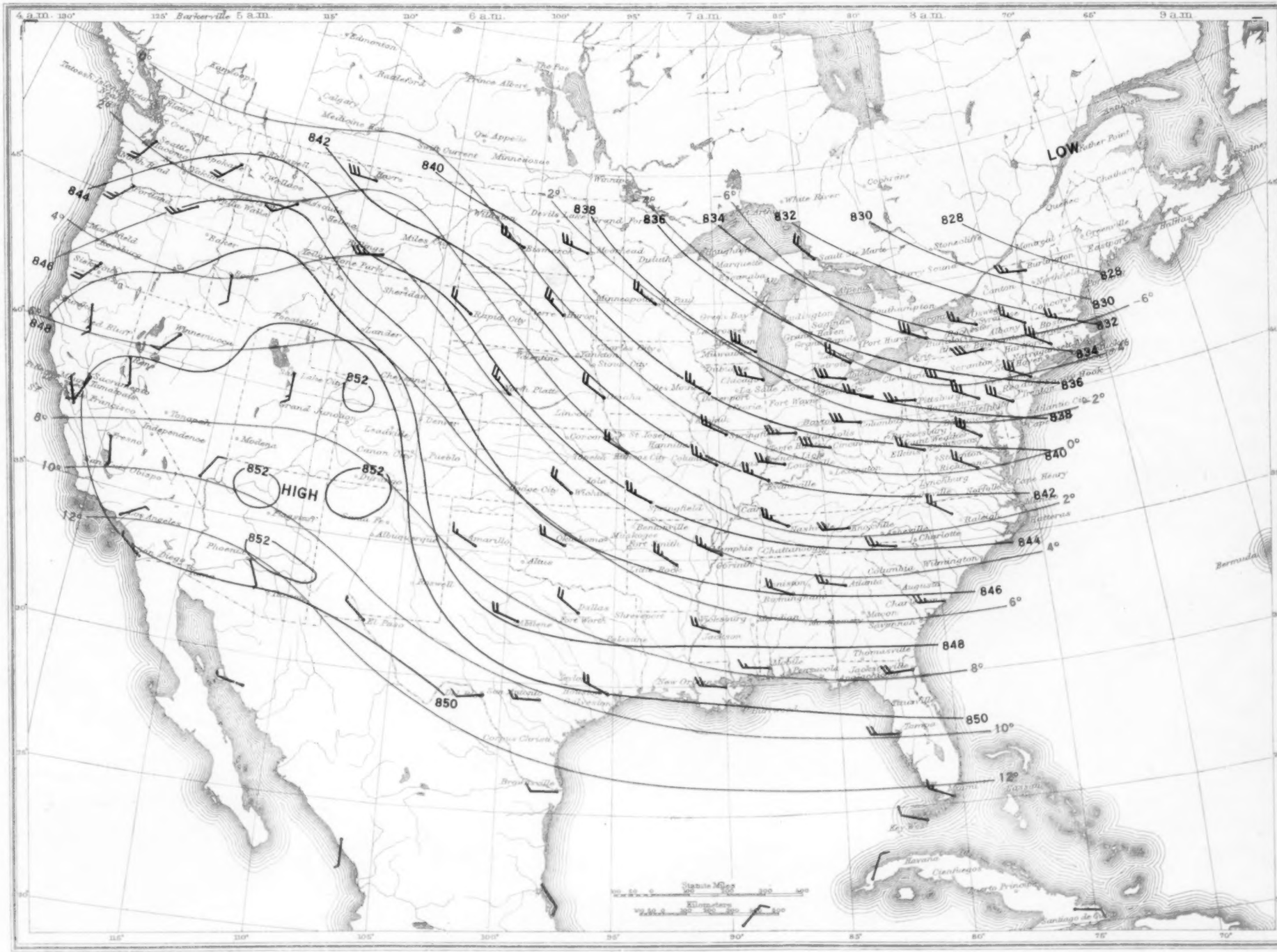


Chart IX. Isobars (mb) Isotherms (°C.) and Resultant Winds for 3,000 Meters (m. s. l.) December 1939

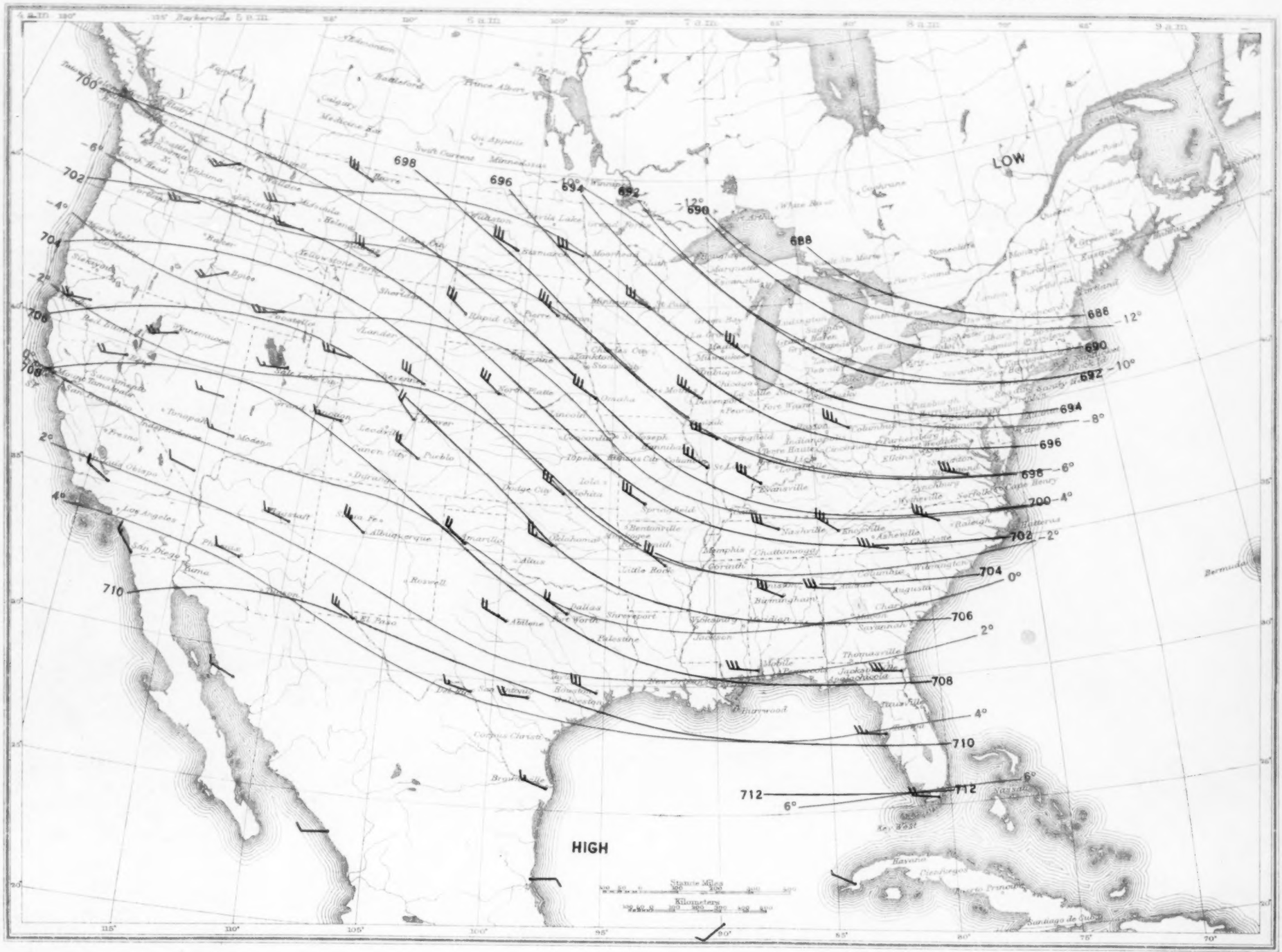


Chart X. Isobars (mb) Isotherms (°C.) and Resultant Winds for 4,000 Meters (m. s. l.) December 1939

Chart XI. Isobars (mb) Isotherms (°C.) and Resultant Winds for 5,000 Meters (m. s. l.) December 1939

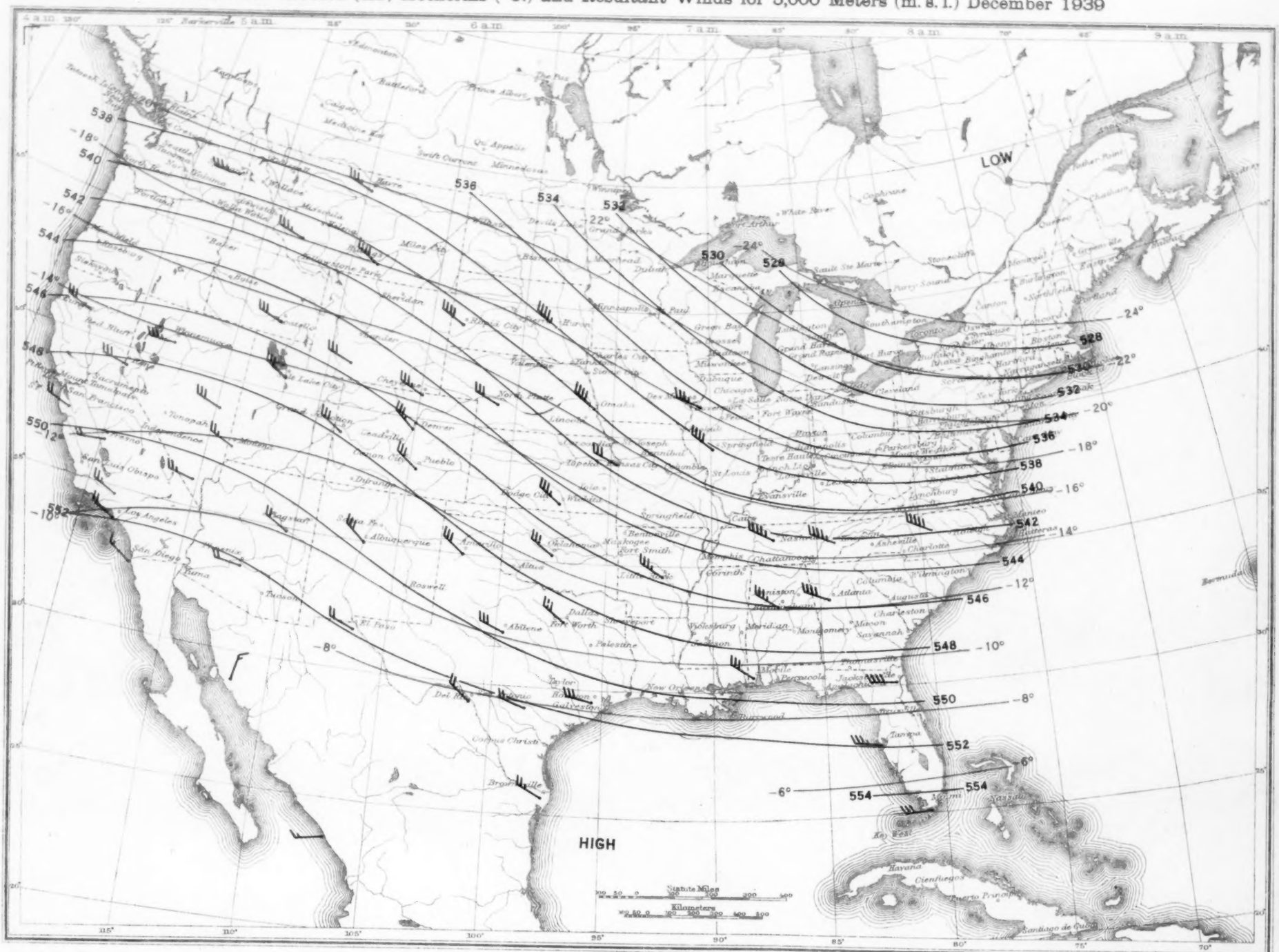


Chart XII. Mean Isentropic Chart, December 1939 (Potential Temperature 300° A.)

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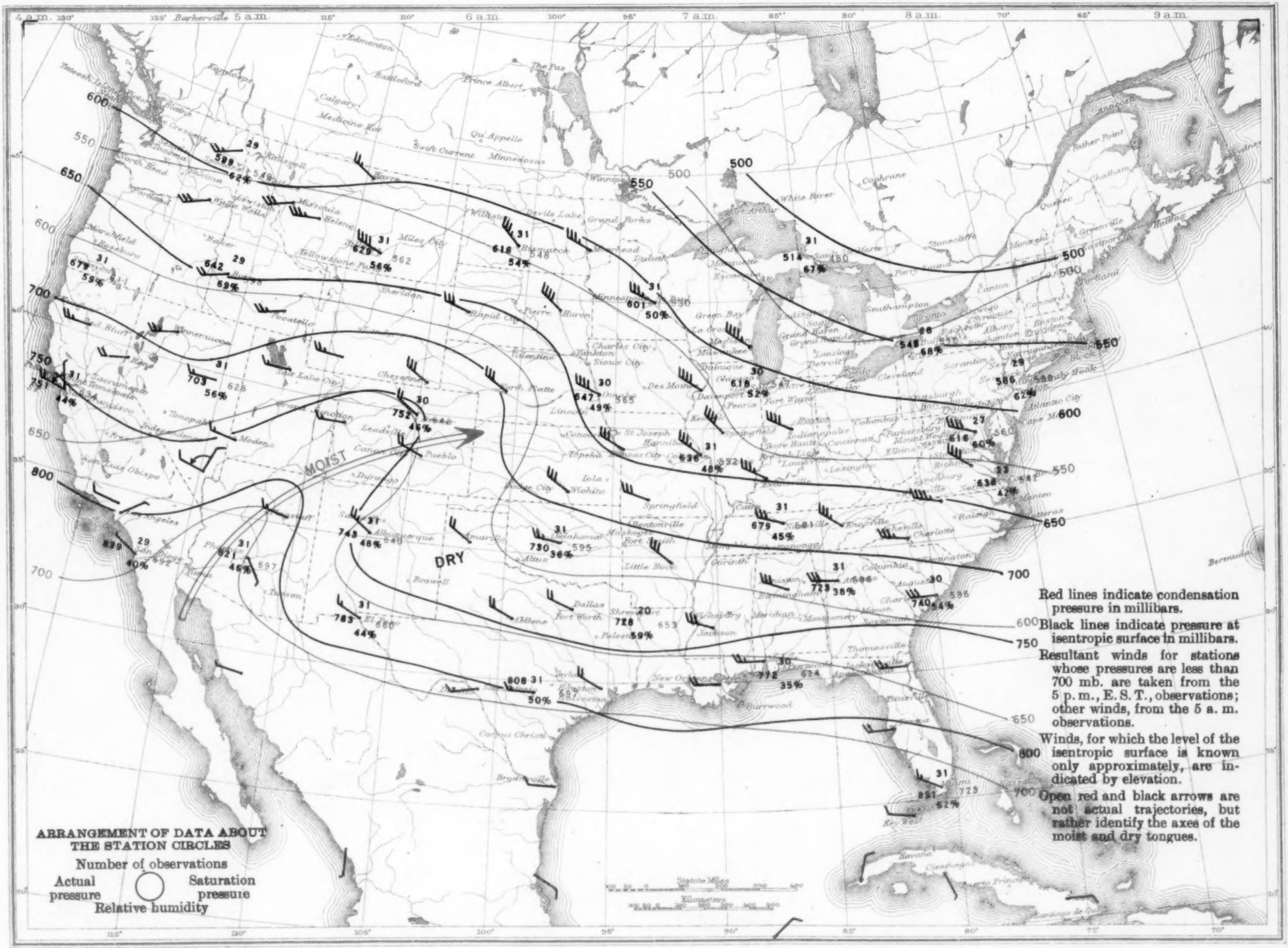
MOIST
DRY
ARRANGEMENT OF DATA ABOUT THE STATION CIRCLES
Number of observations
Actual pressure
Saturation pressure
Relative humidity
Red lines indicate condensation pressure in millibars.
Black lines indicate pressure at isentropic surface in millibars.
Resultant winds for stations whose pressures are less than 700 mb. are taken from the 5 p. m., E. S. T., observations; other winds, from the 5 a. m. observations.
Winds, for which the level of the isentropic surface is known only approximately, are indicated by elevation.
Open red and black arrows are not actual trajectories, but rather identify the axes of the moist and dry tongues.